LANDSCAPE AND HABITAT QUALITY FOR PROBOSCIS MONKEYS: ITS VARIATION IN SPACE AND TIME, AND USE IN MANAGEMENT

by

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STATEMENT ON THE CONTRIBUTION OF OTHERS

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ABSTRACT

The status of Proboscis Monkeys' ecosystems was assessed inside and outside the protected areas of Sarawak. Assessment variables were based on known habitat use of Proboscis Monkeys. Sampling units were laid out in different categories of habitats for assessment of forest structure, food plants, canopy connectivity and human disturbance. Recording of forest attributes was based on rapid assessment, and ecological and forestry survey techniques. Spatial configuration of landscape in the study sites was assessed using satellite imagery. Observation of behavioural activities and foraging behaviour of the monkeys was undertaken in Bako National Park and Kuching Wetland National Park over a period of at least one year. A one-male group was selected from each study site and was followed continuously during the day for three to four days a week. Each age/gender category from the selected one-male group was followed on different days. Feeding, resting, travelling and "other" activities of each category of animal were systematically sampled and recorded in five-minute intervals every 30 minutes from 6:30 am to 6:30 pm. The group was continuously observed outside the five-minute intervals. Patterns of habitat use was formalised into a spatial configuration across the sites and some aspects of the behavioural data was collated and analysed according to that configuration. Behavioural activities occurred within different forest strata and crown levels were also observed and analysed. Feeding behaviour and types of food plants the monkey ate were observed using binocular. Food plants eaten by the monkeys were indentified on the spot after they left the feeding area. Food plants that could not be identified were marked with ribbon taps, photographed and samples were collected. Sampling quadrats were established in the heath and the mangrove forests and phenology of plants inside the quadrats were monitored once a week. Trail users' activities on-trail in Bako National Park were identified and their impacts on Proboscis Monkeys' behaviour were analysed. Observation of the interaction between trail users' activities on-trail and Proboscis Monkeys was undertaken weekdays and over the weekend at the

entry point on selected days of each month. A single stationary vantage point was located 20 m from the entry point which was screened by undergrowth. Each trail user's activity was observed and recorded from the vantage point. A trail user for observation was randomly selected dependent on trail user whose activity firstly triggered the monkeys' response behaviour. If the observed trail user became invisible, another trail user who remained visible was selected from the vantage point. One animal was also randomly selected from the group of Proboscis Monkeys for observation without selecting either female or male. If the observed one disappeared, another one that was visible from the vantage point was selected. Proboscis Monkeys behaviour were observed and recorded in response to trail users' activities on-trail. Interaction was only recorded when there was an encounter from both present at the entry point at the same time. The results suggest that the forest structure and composition in the study sites differed with more small trees colonized the areas. More fragmented habitats were detected outside the study sites. The medium closed heath forest had higher density of food plants, a few emergent trees, and minimal canopy gaps such that more suitable for the monkeys compared to other study sites. Behavioural activities were higher in the habitat of good forest attributes with higher density of food plants. Behavioural activities were significantly higher in the upper crown level and the upper canopy particularly feeding activity. Male monkeys engaged in more feeding compared to females. Feeding was significantly higher during the wet season as opposed to the dry season in Bako National Park. Young leaves were the most preferred food plant parts to all age/gender categories. Feeding on young leaves was significantly different between wet and dry seasons. Higher feeding on young leaves during the wet season coincided with higher foliation of mangrove stands during the same season. This explains the availability of food resources in the mangrove habitat influence feeding and diet category of the monkeys. Lower feeding activity during the dry season at the time when lower availability of food resources contribute to our understanding that the monkey may be more vulnerable to human disturbance during a time of lower food availability and hence at a time when they can least afford it. Specifically, disturbance derived from off-trail and laughing activities inflicted an adversely disturbing effect on the monkeys' foraging behaviour. Moreover these results indicate that human disturbance have more adverse effects on the monkeys' foraging behaviour as opposed to variability in the availability of food resources.

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CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

This chapter provides study aims, significance, research objectives, and thesis outline. The aims and significance of the study are briefly described, whereas the objectives illustrate the scope of investigation on the specific issues. The thesis outline describes how the thesis chapters are organised to facilitate discussion according to the related topics.

1.2 STUDY AIMS

This research aims to investigate changes in habitat use by Proboscis Monkey (*Nasalis larvatus*) in response to resource variability and the impact of human disturbance on foraging behaviour. The research involves assessment of habitat attributes, intensive observation of the monkey's foraging behavior, feeding habit, potential food source, monitoring phenological characteristics of sampled forest stands during wet and dry seasons, and observation of the effect of visitor behaviour on-trail on the monkey's foraging behaviour.

1.3 SIGNIFICANCE

The expected result of the study will show status of habitat quality for Proboscis Monkey, behavioural patterns, foraging behaviour and diet category according to variability of food resources during wet and dry seasons, especially foliation, flowering, fruiting of food plant species, and foraging response-behaviour in relation to trail users' activities on-trail. The results will improve database for park interpretation, provide a value-added ecotourism in the park and the key important aspect of management and long-term conservation of Proboscis Monkey.

The research technique can be applied to a larger scale of research that encompasses the whole part of Sarawak to plan for mitigation and preventive measure for habitat of Proboscis Monkey. The techniques applied in this study could be used to assess habitat quality, habitat use and foraging behaviour for other endangered species in tropical countries.

1.4 RESEARCH OBJECTIVES

The following objectives are set up, specifically to guide the investigation towards achieving the purpose of this research.

1. To investigate whether there is any difference on the status of Proboscis Monkey's habitats inside and outside of protected areas.

1.1 To examine the prominent characteristics and the forest structure of Proboscis Monkey's habitats.

1.2 To investigate the changes in habitat attributes that might occur in these habitat types due to disturbances.

2. To investigate whether there is any difference in behavioural activities of Proboscis Monkey according to habitat characteristics.

2.1 To examine whether behavioural activities of Proboscis Monkey differ in relation to forest strata and crown levels.

2.2 To investigate whether behavioural activities of Proboscis Monkey differ among the age and gender categories.

2.3 To investigate whether there is any variation in monthly behavioural activities of Proboscis Monkey.

2.4 To examine whether wet and dry seasons influence behavioural activities of Proboscis Monkey.

3. To investigate if seasonal change in habitat attributes influences the foraging behaviour of Proboscis Monkey by

3.1 examining whether seasonal fruiting and flowering changes foraging behaviour, and

3.2 documenting the preferred food plants and food items of Proboscis Monkey and seasonal variations in this preference.

4. To investigate how visitors on-trail influence the foraging behaviour of Proboscis Monkey.

1.5 THESIS OUTLINE

Apart from this Chapter 1 the overall structure of this thesis is briefly described below.

Chapter 2 reviews the importance of landscape characteristics and its effect on habitat use by wildlife. The influence of climate variability and its related effects on behavioural activities and foraging behaviour of wildlife are identified. It also examines the effects of human disturbance and habitat fragmentation, and seasonal change in food resources on primate foraging behaviour. Specifically, the ecology of Proboscis Monkey and their social behaviour are briefly described and the effects of fragmented environments on the long-term conservation of these monkeys are also examined.

Chapter 3 describes the study area, and the specific study sites including land-use practice.

Chapter 4 describes the global habitat assessment of primates and the quality of habitat for Proboscis Monkey. It also describes the indicator for the quality of habitat and the technique to assess the quality of Proboscis Monkey's habitat. The different category of Proboscis Monkey's habitats is identified and the results are compared according to indicator for habitat quality. The discussions on these topics are also supported by satellite imagery and the conclusions are drawn with some recommendations toward conservation of Proboscis Monkey and its habitats.

Chapter 5 describes behavioural ecology of primates and Proboscis Monkey. The methods used in this study are a combination of methods used in other related studies. The specific observed behavioural activities are categorised and defined, and the results from the observations are compared. It also examines behavioural patterns of Proboscis Monkey in different habitat types and the affect of seasonal changes in terms of wet and dry seasons on behavioural activities.

Chapter 6 examines specifically on Proboscis Monkey's feeding behaviour according to its age categories. The methods used in this study are based on the methods described in chapter 5. The effect of seasonal changes and the phenology of food plants are also examined. The results from the two study sites are compared and the findings are summarized based on the objectives of the study.

Chapter 7 reviews the wildlife tourism in the protected areas and the interaction between visitor and Proboscis Monkey. Visitor activity on-trail and its effects on Proboscis Monkey's foraging behaviour are thoroughly examined based on a combination of methods. The discussions are focussed on the Proboscis Monkey's response behaviour, and the types and the effects of visitor activity on-trail. It also examines the management implications based on the findings of the study.

Chapter 8 integrates all the study findings including the applications and the disturbance factors. It also integrates and examines the conservation and management implications, and recommends the future research for the long-term conservation of Proboscis Monkey and its habitats in relation to its economic value as an ecotourism product of the Malaysian State of Sarawak.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The influence of climate variability and its related effects on behavioural activities and foraging behaviour of wildlife are identified. It also examines the effects of human disturbance and habitat fragmentation, and seasonal change in food resources on primate foraging behaviour. Specifically, the ecology of Proboscis Monkey and its social behaviour are briefly described and the effects of fragmented environments on the long-term conservation of Proboscis Monkey are also examined.

2.2 LANDSCAPE ECOLOGY AND WILDLIFE HABITAT

2.2.1 Patterns and Process in Wildlife Landscape

Intact natural landscape plays an important role in maintaining the ecological processes of ecosystems. The underlying principle of ecological sustainability is that natural landscapes have to be managed sustainably in order to maintain biodiversity (Lindenmayer, Margules, & Botkin, 2000). Biodiversity-rich landscapes have been diminishing due to land-use practices that have created isolated patches, matrixes and corridors (Turner, Gardner, & O'Neill, 2001). While intact landscapes provide all the requirements for wildlife in terms of shelter, connectivity, food and reproduction, modified landscapes, and the extent and pattern of that modification, affect wildlife behaviour. In New South Wales, Australia, Fischer and Lindenmayer (2002) demonstrated the value of paddock trees for birds in modified landscape. They suggest that paddock trees are a very important potential attribute to enhance connectivity and enable bird movement through the landscape, although different bird species need different habitat requirements. In semi-arid grassland in the Sevilleta National Widlife Refuge, Wiens and Milne (1989) reported that patterns modification influenced the way beetles moved across a patchy landscape.

Certain wildlife species can survive in a modified landscape and some cannot, depending on the pattern and extent of that modification. Greater Gliders (*Petauroides volans*) and Mountain Brushtail Possums (*Trichosurus cunninghami*), for instance, have been found to have survived in forested corridors (Lindenmayer & Nix, 1993). Conversely, similar landscape conditions would not guarantee the survival of the Leadbeater's Possum (*Gymnobelideus leadbeateri*), which needs habitats with an abundance of large old trees with hollows that provide nest sites, a prevalence of under-storey *Acacia* trees that provide a food resource, as well as a much larger habitat size than what is provided in a corridor (Lindenmayer, 2000). The reduction in habitat size is also known to limit the movement of Yellow-bellied Glider (*Petaurus australis*) (McAlpine & Eyre, 2002). Furthermore, marsupials such as Sugar Glider (*Petaurus breviceps*) are rarely found in a patchy landscape of remnant forests (Lindenmayer, Cunningham, Pope, & Donnelly, 1999), indicating that this pattern of fragmentation is not suitable for them. This supports the assertion that the occurrence, distribution and abundance of wildlife are influenced by landscape characteristics such as fragmentation, isolation and patchiness, resources availability, and size of fragments (Harper, McCarthy, & van der Ree, 2008).

Fragmentation that leads to isolated and patchy remnants of forest depreciates the quality of wildlife habitat (Lindenmayer & Nix, 1993) which influences wildlife behaviour (Felix, Linden, & Campa III, 2007). Turner, Gardner and O'Neill (2001) have documented how a modified landscape disturbs wildlife species differently, conditional on their requirements. An example that illustrates the contrast in habitat requirements among wildlife species and the consequences of habitat modification is the study on three species of birds: Middle-Spotted Woodpecker (*Dendrocopos medius*), Wood Lark (*Lullula arborea*), Red-Backed Shrike (*Lanius collurio*) in Leipzig in Northwest Saxony, Germany by Holzkamper, Lausch and Seppelt (2006). Their study found that habitat suitability for these three species of birds in a modified landscape differed. They found that habitat suitability depended mainly on the proportion of deciduous forest for Middle-Spotted Woodpecker, the proportion of coniferous and also deciduous forest for Wood Lark, and the proportion of cropland relative to deciduous forest, coniferous forest and grassland for Red-Backed Shrike.

Some species may go extinct in fragmented landscapes, especially those that occupy lowland areas, wetlands (Turner, Pearson, Bolstad, & Wear, 2003), riverine and coastal habitats because the quality of these areas has been degraded as a result of land-use practices occurring close to waterways, in many instances resulting in the drainage of these areas. As landscape changes vary, the complexity of the changes in terms of process and pattern and the effects of that changes on wildlife can best be explained by the habitat contour model (Fischer, Lindenmayer, & Fazey, 2004) in relation to their varying nature of impacts on habitat suitability. Tyre, Possingham and Lindenmayer (1999)'s model on Greater Gliders (*Petauroides volans*) showed that continuous spatial variation in habitat quality affects the reproduction of the Greater Glider; i.e. fecundity increases above the average habitat quality but decreases below the average habitat quality.

Furthermore, wildlife responds noticeably to the status or quality of their habitat at the spatial scale. For example, for the American Marten (*Martes americana*), which is very sensitive to habitat fragmentation and occurrence of late seral forest, habitat selection is dependent on forest types (Bissonette, Harrison, Hargis, & Chapin, 1997; Wasserman, Cushman, Schwartz, & Wallin, 2010). On the other hand certain wildlife species, for example the Eastern Timber Wolves (*Canis lupus lycaon*) in the upper Midwestern United States will move throughout the modified landscape to meet their needs (Turner et al., 2001). Generally, quality of habitat is associated with availability and suitability of resources (Turner, Pearson, Romme,

& Wallace, 1997), spatial and temporal availability of food resources (Lindenmayer, Cunningham, & McCarthy, 1999), and the structure and composition of the forest (Lindenmayer, Cunningham, Tanton, Nix, & Smith, 1991).

The intrinsic relationship between wildlife and habitat quality (Lawson, Goosem, & Gillieson, 2008; Lindenmayer, McIntyre, & Fischer, 2003) was not well understood until the introduction of landscape ecology by the German biogeographer, Carl Troll (Turner, 2005b). The concept not only emphasizes size but also encompasses the consequences of spatial patterns (Turner, 2005a, 2005b; Turner, O'Neill, Gardner, & Milne, 1989) which are quantified by landscape metrics (Bolliger, Wagner, & Turner, 2007; Hargis, Bissonette, & David, 1998). An understanding of the interaction between wildlife species and habitat is essential to the conservation and management of landscape for wildlife. Previous work focussed on multi-scale patterns (Fischer, Lindenmayer, & Manning, 2006; Lindenmayer et al., 2000; Tyre, Possingham, & Lindenmayer, 2001), including spatial configuration of suitable habitat for a given wildlife species (Ritchie, 1997). However, habitat quality is wildlife species specific (Storch & Bissonette, 2003), and species respond differently to habitat changes (McAlpine et al., 2006; Wiersma, Nudds, & Rivard, 2004), variation in the landscape matrix (Lindenmayer & Lacy, 2002), and landscape-level variables (Koper & Schmiegelow, 2006; McCarthy& Lindenmayer, 2000).

2.2.2 Habitat Heterogeneity and Use by Wildlife

Changes in landscape are influenced by both human activities and natural phenomenon. Changed landscape as suggested by Lindenmayer and Fischer (2006) refers to fragmented, modified, sub-divided, isolated and degraded landscape. These changes have an influence on ecosystem processes (O'Neill et al., 1997), and also have some effects on biodiversity, habitat use by wildlife, and a number of ecological functions (Turner, 1989). The impacts of landscape change are categorised as exogenous and endogenous. Exogenous threats originate independently or externally to a species' biology. For example, in habitat loss due to landscape modification, species may decline, or occur at lower density, or may be unable to breed as a result of habitat degradation or loss of nest sites, and day-to-day movements of a given species can be restricted due to habitat isolation (Fischer & Lindenmayer, 2007). On the other hand, endogenous threats arise as part of a species' biology, for example altered breeding patterns and social systems, behavioural and biological changes including disruptions to dispersal, and changes to species interactions which may affect competition, predation, parasitism and mutualisms (Fischer & Lindenmayer, 2007).

There have been many studies on the response of wildlife to landscape changes particularly variability of responses from species to species in different landscape environments, for example Bissonette and Storch (2003), Fischer and Lindenmayer

(2007), Lindenmayer, Cunningham, Donnelly, Nix and Lindenmayer (2002), Lindenmayer et al. (2008), McCarthy, Lindenmayer, and Possingham (2001) and Whitehead, Woinarski, Franklin and Price (2003). Changes in landscape patterns affect habitat use by wildlife (Pearson, Turner, & Drake, 1999) although some show resilience (Fischer et al., 2007; Peterson, 2002; Peterson, Allen, & Holling, 1998) through processes of adaptive capacity such as the ability to adapt behaviourally to disturbances (Lindenmayer et al., 2008; Manning, Gibbons, & Lindenmayer, 2009; Sendzimir, Allen, Gunderson, & Stow, 2003). Wildlife responses are characterised by different features of habitat and types of landscape changes (Fischer & Lindenmayer, 2007). While the changes in landscape influence the distribution and abundance of wildlife species (Lindenmayer & Luck, 2005), ability to adapt varies both spatially and temporally (Lindenmayer et al., 2008; Travis, 2003) depending on the frequency (Turner, 1989) and magnitude of changes (Turner, Dale, & Everham III, 1997).

Although most landscape changes are induced by human activities, the extent of changes in terms of frequency and magnitude are further exacerbated by environmental factors. In a more sensitive landscape, the impact of landscape changes lead to critical thresholds in the landscape matrix (Donovan & Strong, 2003) and create habitat isolation (Andren, 1994). The decline in sugar maple forests in north-eastern United States as reported by Bissonette and Storch (2002) is a good example of how landscape change through time has reached the landscape threshold. Such a threshold implies an abrupt change in the ecosystem quality which negatively affects animal behaviour (Groffman et al., 2006). Wildlife occurrence patterns are negatively influenced by isolated habitat patches that are completely surrounded by a cleared landscape, because wildlife are unlikely to experience reproductive or foraging success in relation to high risk of crossing the matrix (Bissonette, 2003; Wilson, Johnson, & Bissonette, 2009).

Driving forces for landscape changes are categorized as deterministic and stochastic forces. Deterministic threats lead to decline of wildlife species whereas stochastic threats are related to environmental variability such as fluctuation in climate that leads to year-to-year variability in reproductive success and genetic drift (Fischer & Lindenmayer, 2007). Either one of these threats or both will impede the movement of wildlife, depending on the nature of connectivity (Taylor, Fahrig, Henein, & Merriam, 1993), carrying capacity (Vos, Verboom, Opdam, & Ter Braak, 2001) and perturbation degree of the deteriorated landscape (Travis, 2003). However, changes in landscape due to human disturbance are defined by number, size and shape of patches which are characterized by alteration of both structure and function of the ecosystem (Turner, 1989). Indeed, patch size and shape of habitat are very important to understand the ability of wildlife to persist in a fragmented landscape. This is because patch size and shape of habitat determine suitability of habitat for a given wildlife species in terms of vegetation characteristics such as understorey structure (Lindenmayer, Cunningham, & Pope, 1999).

Deterministic changes in landscape as a result of anthropogenic activities have been well established. Being one of the determinants of deleterious effects on landscape patterns, human-induced impacts are both continuous and discontinuous events, including habitat fragmentation, elimination and introduction of species (Belovsky et al., 1994). The implications of these changes include alterations to wildlife habitat and declination in biodiversity (Turner, Gardner, & O' Neill, 1995), although the disturbed habitat may recover through succession processes (Johnson, 2000) and colonisation by other species. Clearly fragmentation not only causes landscape cover and native vegetation loss, but also eliminates suitable habitat for wildlife species (Lindenmayer & Fischer, 2006). Besides fragmentation and habitat loss, landscape modification, sub-division and degradation are also commonly used to describe the consequences of human-modified environment through deforestation and urban expansion (Lindenmayer & Fischer, 2006).

2.2.3 Effects of Climate Variability

Variation in global climate either discontinuous or continuous, impacts on the natural landscape. Changes in global climate system have influenced localised climate variability. There have been many examples of the impact of climate variability on wildlife (Ledley et al., 1999). For example, varying climate conditions, particularly rising and extreme temperatures, will result in lowland biotic attrition (Colwell, Brehm, Cardelús, Gilman, & Longino, 2008), species population declination (Mote et al., 2003; Opdam & Wascher, 2004; Scavia et al., 2002), extirpation or extinction (Thomas et al., 2004; Williams, Bolitho, & Fox, 2003), and migration and adjustment (Holt, 1990; Morrissette, Bety, Gauthier, Reed, & Lefebvre, 2009), amongst others. Climate variability associated with rainfall resulting in distinct wet and dry seasons is known to affect the distribution pattern of wildlife, for example changes in distribution of the endangered Gouldian Finch(*Erythrura gouldiae*) in northern Australia as documented by Lewis (2007). Changes in distribution of wildlife are due to production and distribution of resources which differ monthly according to species (Hemingway & Bynum, 2005). Thus, climate variability affects both availability of resources and wildlife foraging behaviour. It has further been argued by Gutzwiller and Riffell (2007) that wildlife response (response variable) to a combination of explanatory variables, for example availability of resources, as a result of climate variability.

Wildlife response to climate variability associated with temperature changes as displayed by their foraging behaviour is subject to their resource requirements. This has been demonstrated by McCarty (2002) in a study of birds which identified that their requirements for fruits fluctuated due to variability of climate. He suggests that wildlife can be selective based on their needs in relation to the changing habitat condition over time. Certain bird species are very sensitive to drastic change in climate, for example Storch (2007) found that populations of Capercaillie (*Tetrao urogallus*) decline over time due to fluctuations in summer rainfall, although the quality of habitat does not change significantly. His study also indicated that variability in climate not only affects foraging activities but also quality of food plants required by this bird for reproduction. In addition, an early study by Bissonette (1978) suggests that high summer temperatures restricts foraging activities of Peccaries (*Dicotyles tajacu* Linnaeus) and forces this bird to forage throughout the night to fulfil their energy needs. He further suggests that cold winter temperatures, on the other hand has forced this bird to eat more during winter to maintain its body weight although the quality of vegetation is lower during this season. This indicates that variability of climate has changed the foraging behaviour of this bird in relation to summer and winter seasons. Therefore, variation in wildlife habitat is also associated with the variation in resource availability over time as a result of climate variability. Thus, variability in resource abundance and quality has significant effects on wildlife species (Bissonette, 2007).

Moreover, resource variability and its effects on wildlife are caused by various factors (Lindenmayer, 2000) including seasonality, phenological events, trophic relationships or disturbance (Bissonette, 2007). For example, for introduced birds in New Zealand, resource variability influenced their niche opportunities (MacLeod, Parish, & Robinson, 2007). Apart from this, longer breeding seasons which are associated with less variation in resource availability are due to reduced seasonal variation in climate (Evans, Duncan, Blackburn, & Crick, 2005). Thus, a slight change in resource availability over time within the wildlife habitat as a result of climate variability will affect wildlife fitness (Grimm, Stillman, Jax, & Goss-Custard, 2007).

2.3 PRIMATE AND HABITAT QUALITY

2.3.1 Factors Affecting Quality of Primate Habitat

The quality of habitat for primates is important to the survival of the species, and is under threat due to unsustainable land-use practices that inflict adverse effects on primates' and arboreal primates' behaviour in particular. The quality of habitat for primates is affected by many factors including habitat fragmentation, habitat loss, modification in tree canopy, changes in vegetation composition and structure, changes in species diversity, and decline in quality and quantity of food resources (Arroyo-Rodríguez & Dias, 2010; Arroyo-Rodríguez & Mandujano, 2006; Arroyo-Rodríguez, Mandujano, & Benítez-Malvido, 2008; da Silva Junior et al., 2009; da Silva Junior, de Melo, Moreira, Barbosa, & Meira-Neto, 2010; Marshall, 2010; Pyritz, Büntge, Herzog, & Kessler, 2010).

Most primates have specific habitat requirements that determine their population density. These primates' habitat requirements are dependent on the quality of habitat types that influences their foraging activities (Barton, Whiten, Strum, Byrne, & Simpson, 1992). The quality of habitat not only affects primates' behaviour (Chauhan & Pirta, 2010; McCarthy et al., 2009) but also determines the long-term survival of primates. While different species of primates may demonstrate different levels of tolerance to habitat fragmentation, habitat structure and anthropogenic disturbance are known to affect primate abundance (Pyritz et al., 2010). Even habitat destruction that leads to habitat loss has caused decline in populations and eventually extinction in many primates' populations (Chapman & Peres, 2001; Meijaard & Nijman, 2000a, 2000b). Habitat loss decreases patch size and hence food availability which subsequently diminishes population density of primates (Arroyo-Rodríguez & Dias, 2010). It is clear that the occupancy of primates in disturbed habitat is related to patch size and food availability because vegetation cover varies among different fragmented landscapes (Arroyo-Rodríguez et al., 2008). Additionally, the smaller the patch size the lower the density of large trees and plant richness which in turn affect daily behavioural activities of primates (Hopkins, 2011; Madden, Garber, Madden, & Snyder, 2010).

The abundance of primates is also related to vegetation attributes such as the abundance, and basal area of major food resources (Arroyo-Rodríguez & Mandujano, 2006; Balcomb, Chapman, & Wrangham, 2000; Chapman, Struhsaker, Skorupa, Snaith, & Rothman, 2010). For example, Howler Monkeys (*Alouatta* *palliata*) in Los Tuxtlas, Mexico are able to survive in small fragmented habitat due to greater density of large trees, greater basal area of persistent tree species, and greater basal area of top food species (Arroyo-Rodríguez, Mandujano, Benítez-Malvido, & Cuende-Fanton, 2007). However, fragmented habitat affects the availability of food resources that leads to reducing primate density and changing primate behaviour (Cristóbal-Azkarate & Arroyo-Rodríguez, 2007). Therefore the ability of primates to maintain their population density in habitat fragments is due to availability of food resources. Even the availability of specific or preferred food resources may affect the quality of habitat for certain primate species. For example, in Kalimantan, Indonesia, specific types of food resources determine the quality of habitat for Red Leaf Monkeys (*Presbytis rubicund rubida*) rather than general measures of the availability of food resources (Marshall, 2010).

Despite the ability of primates to consume different types of food resources in low quality habitat, new habitat established through natural recruitments and succession processes would not guarantee primates' survival. Moreover, the primates have to move or migrate to any suitable patches to fulfil their needs for quality resources (Asensio, Arroyo-Rodríguez, Dunn, & Cristóbal-Azkarate, 2009). This is because patches created through fragmentation exhibit modified microclimates which lead to changes in composition and also structure of plants (Arroyo-Rodríguez & Dias, 2010). These phenomena also support Arroyo-Rodriquez and Mandujano (2006) that the effect of fragmentation has been a reduction in the quality of habitat for the Howler Monkey (*Alouatta palliata*), leading to an acceleration in their mortality rate (Ferreira & Laurance, 1997; Laurance, Delamônica, Laurance, Vasconcelos, & Lovejoy, 2000) through a collapse of biomass (Laurance et al., 1997) in food plants for the monkey.

As for White-bearded Gibbons (*Hylobates albibarbis*) in Gunung Palung National Park, Kalimantan, Indonesia, Marshall (2009) suggests that the lower probability of occurrence of these primates in the isolated habitat is partly due to low density of preferred food plants. He further argues that due to the small and isolated area of Gunung Palung National Park, plant communities are compressed such that the food plants are scarce along the elevational gradient. In the case of Woolly Spider Monkey (*Brachyteles hypoxanthus*) in Atlantic Forest in Minas Gerais State, the quality of habitat is related to the abundance of food plants which become an indicator for the abundance of this monkey (da Silva Junior et al., 2010). This is because food plants characterized by large trees with strong branches in Atlantic Forest improve locomotion security (Fimbel, 1994), decrease predation and allow the formation of tight groups of the monkey (da Silva Junior et al., 2010). Manansang, Traylor-Holzer, Reed and Leus (2005) suggest that the alarming rate of deforestation is a serious threat to the quality of habitat for Proboscis Monkey because it leads to the loss of food plants and the triggering of disease epidemics. Overall, habitat fragmentation and habitat loss have been the main factors diminishing the quality of habitat for primates because they not only alter the primate habitats but also reduce and damage all the necessary requirements for survival.

2.3.2 Factors Affecting Primate Foraging Behaviour

The type and quality of habitat are important determinants of primate survival. Different habitat types provide different foraging opportunities for primates (Curtis & Rasmussen, 2006), which in turn influences their foraging activity (Barton et al., 1992), and survival. Quality habitat provides a level of critical resources especially in the heterogeneous habitat (Sullivan & Sullivan, 2001). Heterogeneous forest habitat provides spatial heterogeneity of food for many primates and other wild animals (Barton et al., 1992). Heterogeneous habitat supports larger populations of primates (Brugiere, Gautier, Moungazi, & Gautier-Hion, 2002) because they can access various choices of diet categories among the available food resources. Thus, diversity and continuous availability of resources determine the quality of foraging habitats for most primates (Marshall, 2009; Marshall, Boyko, Feilen, Boyko, & Leighton, 2009), although some species have a fairly restricted diet for example, Chimpanzees (*Pan troglodytes*), Baboons (*Papio anubis*) and Guenons (*Cercopithecus* spp.).

Any changes in habitat resources affect primates' foraging behaviour (Snaith & Chapman, 2007; Struhsaker et al., 2004) due to changes in the quality (Dela, 2007; Grueter et al., 2009; Takemoto, 2004), distribution and availability of resources (Martins, 2008; Zhou, Tang, Huang, & Huang, 2011). Habitat productivity is influenced by seasonality and produces dietary variability for primates (Chapman & Lauren, 1990; van Schaik, Terborgh, & Wright, 1993). Seasonality in terms of wet and dry seasons influence the phenology and productivity of resources that leads to changes in food resource availability during certain months within these two seasons (Moreau et al., 2010; Staggemeier & Morellato, 2011; van Schaik et al., 1993). In upper Urucu river, western Brazilian Amazonia, Peres (1994) documented that the phenology of food plants influenced the movement of primates during foraging. Certain plant species became critical food during the dry season (Peres, 1994) and hence affected activity budgets of primates (Brugiere et al., 2002; Tsuji, 2010).

Variability in production of food resources, in terms of quantity and type, influences diet selection at various times of the year (Wasserman & Chapman, 2003) and foraging behaviour (Chapman, Chapman, & Gillespie, 2002; Kirkpatrick, 2007; Lambert, 2007), especially feeding activity of many primates (Harris, Chapman, & Monfort, 2010; Hemingway & Bynum, 2005) including Proboscis Monkey (Bennett & Davies, 1994; Boonratana, 2000; Yeager, 1989a). Despite this variability in food resources (Thorén et al., 2011; Zhou et al., 2011) primates show flexibility in food items consumed (Chapman, 1988b). They can switch their diet during periods (seasons or months) of food scarcity (Thorén et al., 2011). During these periods some primates have to consume ‘fallback food’ (Grueter et al., 2009;

Marshall et al., 2009), food which is not preferred but necessary because they have limited choice (Brugiere et al., 2002). For example, in Kibale National Park, Uganda Redtail Monkeys (*Cercopithecus ascanius*), Olive Baboons (*Papio cynocephalus*) and Chimpanzees (*Pan troglodytes*) consume agricultural crops (for example maize and/or bananas) when natural food resources are limited (Pienkowski et al., 1998).

Different species of primates, either leaf-eating or fruit-eating monkeys, alter the type and quality of food item during food scarcity depending on their nutritional requirements (Marshall et al., 2009). For example, Colobus Monkeys (*Colobus* spp.), which need higher energy food in their diet are able to respond to the scarcity of food by consuming fallback food such as digestible mature leaves, and other low-quality foods resources (Milton, 1980; Wasserman & Chapman, 2003). Chimpanzees (*Pan troglodytes*) do not change their diet during food scarcity (Tutin, Ham, White, & Harrison, 1997) unless in fragmented landscapes where food resources are limited. In semi-arid Africa, Chimpanzees are facing various threats including scarcity in water and food resources (Duvall, 2008). Often a fragmented habitat is not only unable to provide refugia for these primates but poor connectivity affects their foraging behaviour by reducing their access to feeding sites (Campbell, Kuehl, Diarrassouba, N'Goran, & Boesch, 2011).

Primates prefer to feed near sleeping sites if food is in abundance (Twinomugisha & Chapman, 2007). This is consistent with a study by Chapman, Chapman and McLaughlin (1989) which showed that Spider Monkey occurrence at sleeping sites was related to availability of food resources. Furthermore, Spider Monkey sleeping site selection was related to travel costs to feeding sites (Chapman et al., 1989). Although distribution and availability of food resources influence foraging behaviour of primates (Chapman et al., 2002; Chapman et al., 2010; Milton, 1980), they do not travel far from their sleeping sites during food scarcity (Pienkowski et al., 1998). Some will remain inactive during certain months of the year to preserve energy (Snaith & Chapman, 2005, 2007). Variations in availability (type, quantity, quality) and distribution (sparse vs clumped) of food resources (Hoffman & O'Riain, 2011) influence primates movement in relation to their foraging behaviour which in turn affects the home range used by primates (Twinomugisha & Chapman, 2007).

Forest structural attributes also influence foraging behaviour of primate especially heights of trees (Bitty & McGraw, 2007; MacKinnon & MacKinnon, 1980) and orientation and position of tree branches because the movement of arboreal primates is associated with availability of food resources at the tip of branches (Cant, 1992) in the different stratums of forests (Bennett, 1986a; Overdorff, 1996). The availability and quality of food resources such as leaves (Harris et al., 2010; Hladik, 1978a; Isbell, 1991; Lowman, 1995) suggest that folivorous primates most frequently forage in the upper canopy. Spending most of the time foraging in tree canopy is a common behaviour of arboreal colobines (Agoramoorthy & Hsu, 2005; Bennett & Gombek, 1993; Boonratana, 2000; Matsuda, Tuuga, Akiyama, & Higashi, 2008; Yeager, Silver, & Dierenfeld, 1999) and other folivorous arboreal primates (Rasoloharijaona, Randrianambinina, & Zimmermann, 2008). This is particularly the case in tropical rain forest because food resources especially young leaves are ever-present (Harris et al., 2010; Hladik, 1978a; Isbell, 1991), at the upper canopies (Lowman & Moffett, 1993) at different months in the year and during both dry and wet seasons according to species (Hemingway & Bynum, 2005; Hladik, 1978b; Medway, 1972; Wright & Schaik, 1994). Foraging behaviour is influenced by availabitiy of food resources, for example Proboscis Monkey that consumed more fruits or leaves in certain months of the year (Matsuda et al., 2009a; Yeager, 1985). This is partly due to the timing of the production of certain food resources (for example, new leaves or shoots) especially in mangrove stands which occurs during the wet season (Coupland, Paling, & McGuinness, 2005). Some mangrove stands regularly foliate (Nowak, 2012) especially *Sonneratia alba* (Coupland et al., 2005) and *Avicennia marina* (Duke, 1990) which in turn influences the foraging behaviour of primates which feed on these species. Wasserman and Chapman (2003) suggest that most folivorous primates engage more in feeding on those high quality food items which will maintain their energy balance requirements and avoid nutrient deficiency. Primates maintain an energy balance by reducing the basal metabolic rate (McNab, 1978), for example

Proboscis Monkey which has the lowest metabolic rate of any colobine (Chivers, 1994; Chivers & Hadlik, 1980; Dierenfeld, Koontz, & Goldstein, 1992).

Some diurnal primates (for example *Alouatta palliata* and *Atlese geoffroyi* in Costa Rica, *Cercopithecus Ascanius* in Kibale National Park and *Lemur catta* in Madagascar) vary in the degree of colour vision they possess (Yamashita, Stoner, Riba-Hernández, Dominy, & Lucas, 2005) which can influence levels of feeding on a particular food items and/or choice.

Besides habitat attributes and seasonality in food plant productivity, age of primates also determines foraging behaviour especially the choice of food items (Milton, 1981). Even different gender categories of the same species of primates exhibit different feeding behaviour. For example the feeding behaviour of the lactating female in a study group of Chimpanzee (*Pan troglodytes schweinfurthii*) differed from that of other members of the same group (Bates & Byrne, 2009). Some female primates feed more than males (White et al., 2007) due to difference in body size (Fleagle & Mittermeier, 1980), nutritional requirements (Hoffman & O'Riain, 2011) and metabolic rate (Clauss et al., 2008; Ross, 1992; Schmid & Speakman, 2000). The higher nutritional requirements and metabolic rate associated with gestation and lactation period in female primates (Bates & Byrne, 2009; Lee, Majluf, & Gordon, 1991), means they have different feeding requirements (Bates & Byrne, 2009).

Despite a preference to forage in groups the availability of food determines primate group size, social behaviour and organization, which in turn affects their foraging behaviour (Fiore, 2004; Hon & Gumal, 2004; Rajanathan, 1992). Foraging in a group is most important for young individuals because, until they have matured, they have to learn feeding techniques, and type of food to consume (Rapaport & Brown, 2008; Watts, 2005). This also enhances their ability to detect location, distribution and availability of food resources (Dominy, Lucas, Osorio, & Yamashita, 2001).

2.4 PROBOSCIS MONKEY

2.4.1 Distribution

Proboscis Monkey or long-nosed monkeys are in the family of Cercopithecidae and are endemic to Borneo, occurring in Indonesia (Kalimantan), Malaysia (Sabah and Sarawak), and Brunei Darussalam. They are not found throughout the whole of Borneo, and their distribution ranges from the mangroves and small islands in the coastal deltas, along virtually all major rivers to numerous inland sites (Meijaard & Nijman, 2000a).

They occur mostly within lowland areas up to 50 km inland (Bennett & Gombek, 1993). The only populations that occur far inland, beyond 50 km, in Borneo are found in four locations:

a. Danau Sentarum National Park, West Kalimantan (Manansang et al., 2005; Meijaard & Nijman, 2000a);
b. Upper Sungai Barito, Central Kalimantan (Bennett & Gombek, 1993);
c. Mahakam Lakes, East Kalimantan (Manansang et al., 2005; Meijaard & Nijman, 2000a); and
d. Maliau Basin Conservation Area (Bennett & Gombek, 1993).

Kalimantan

Meijaard and Nijman (2000a) observed that the Proboscis Monkey's population ranged from the coast to inland areas in Kalimantan. About 58 per cent of the population was located in coastal areas and 50 km from the coast, 16 per cent was located between 50 and 100 km, and 18 per cent between 100 and 200 km from the coast. Smaller proportions of the population (8%) were also found between 200 and 750 km from the coast. Most of these monkeys are found at altitudes less than 200 m (Meijaard & Nijman, 2000a). Their occurrence in Danau Sentarum National Park is the furthest inland with an altitude between 35 and 50 m (Manansang et al., 2005). Danau Sentarum National Park and Mahakam Lakes are the only inland wetland habitats of these monkeys in Kalimantan which are isolated from the coastal areas. An approximate population figure of 7,500 Proboscis Monkey was reported in Kalimantan by Meijaard and Nijman (2000a) with large populations at:

a. Tanjung Puting National Park,

b. Sg. Sesayap, Sg. Sebuku, Sg. Sembakung,
c. Danau Sentarum Wildlife Reserve,
d. Kendawangan Nature Reserve,
e. Central Kalimantan river (Kahayan river, Barito river)

A decline in populations of Proboscis Monkey in Kalimantan is due to habitat loss (Meijaard & Nijman, 2000b) and hunting (Meijaard & Nijman, 2000a). Some Proboscis Monkey's habitats in Kalimantan have been cleared for infrastructure and agriculture development (Meijaard & Nijman, 2000a). Although the latest report by Manansang et al. (2005) indicates that the number of Proboscis Monkey in the wild is more than 10,000 individuals, it still has an unacceptable risk of extinction due to continuous high rates of illegal deforestation. According to Bennett and Gombek (1993) only Tanjung Puting National Park and Gunung Palung National Park remain large enough to sustain a population if isolated. In other parts of Kalimantan which are not protected, the existing populations are too small to be viable in the long-term if isolated because forest fires are becoming more frequent and severe – due mostly to anthropogenic factors (Manansang et al., 2005).

East Malaysia

In the last three decades, some Proboscis Monkey's habitats in the lowland areas, particularly coastal and riverine areas, have been reduced and fragmented due to infrastructure and agriculture development (Meijaard & Nijman, 2000a). The only population found at an altitude of 650 m is at Maliau Basin Conservation Area, in the Malaysian State of Sabah, which is approximately 600 km from the coast (Hazebroek, Adlin, & Sinun, 2004) and also isolated from the coastal areas. Over 25 years ago the population of Proboscis Monkey in the Malaysian State of Sabah had been reported at about 2,000 individuals (Salter & MacKenzie, 1985), with the main population areas in the Kinabatangan Delta and along the river systems. In contrast to this, the minimum population size of Proboscis Monkey in the Malaysian State of Sabah was estimated to be close to 6,000 individuals with the stronghold located on the east coast along the lower parts of the Kinabatangan and Segama regions (Sha, Bernard, & Nathan, 2008). Some of these areas have been gazetted as wildlife sanctuaries where habitats and populations of Proboscis Monkey are being protected.

In the Malaysian State of Sarawak, Salter and MacKenzie (1985) documented that Proboscis Monkey was widely distributed, primarily along and near the coast but also up to 55 km (straight-line distance) inland along some of the larger river systems. The main location of the species was the western part of Sarawak, between Samunsam Wild Life Sanctuary on the west and Rejang Delta on the east. Surveys done by Salter and MacKenzie (1981) clearly showed population estimates of Proboscis Monkey in three specific locations, namely Samunsam Wild Life Sanctuary (54-75 individuals), Maludam Forest Reserve (47 individuals) and Bako National Park (106-144 individuals). Total population of Proboscis Monkey in

Sarawak according to Bennett (1988) was as low as 1,000 individuals. Since these studies the exact population of Proboscis Monkey in the Malaysian State of Sarawak is unknown. Bennett and Gombek (1993) have produced a map showing the distribution of Proboscis Monkey at six locations in Sarawak. Five of these locations have been gazetted as totally protected areas, namely Bako National Park, Samunsam Wild Life Sanctuary, Kuching Wetland National Park, Maludam National Park, and Ulu Sebuyau National Park. Another one which is not gazetted yet but already proposed as a Totally Protected Area is Bruit National Park. Among these areas, only Maludam National Park and Ulu Sebuyau National Park are isolated from the coast.

Brunei Darussalam

Brunei Darussalam has a common border with the Malaysian State of Sarawak which divides the small country into two parts. As a result, it is impossible to determine the number of Proboscis Monkey living exclusively in this country. The main centre of Proboscis Monkey distribution is in the Brunei Bay area (Bennett, 1988) and Padas Bay, and is restricted to mangrove forests (Bugna, 2002). These include Pulau Berambang, Pulau Siarau, a stretch of coast between Pulau Siarau and the Sungei Labu (Labu Creek), and east to the Batang (river) Trusan (Mittermeier, 1981). Most of these mangroves are still intact and the existing shrimp farming does not show significant impact on mangroves as the industry is small and the government strictly controls its expansion (Nekman, 2004). As reported in Salter and MacKenzie (1985), census counts done by MacKenzie from 1982 to 1983 estimated 420 individuals at nine different mangrove areas in Brunei Darussalam. Bennett (1988) estimated no more than 300 individuals in whole Brunei Bay area. While there is no recent study to confirm this figure, the current status of Proboscis Monkey's population in Brunei Darussalam is unknown.

2.4.2 Habitat Use

The main habitats of Proboscis Monkey are coastal forests, (Bennett & Gombek, 1993; Meijaard & Nijman, 2000a), river banks and riverine forests (Bennett & Sebastian, 1988; Meijaard & Nijman, 2000b; Yeager, 1989a, 1991a), including coastal mangrove forests (Bennett, 1988; Salter & MacKenzie, 1985), and peat swamp forests (Bennett, 1988; Jeffrey, 1982). Because their habitats are closely associated with waterways, with individuals returning to the water's edge in the evening, they are rarely ranging far from rivers, generally < 1 km (Bennett & Sebastian, 1988; Davies & Oates, 1994; Meijaard & Nijman, 2000a). However, Proboscis Monkey's habitats are not limited to the coastal and down stream areas of rivers (Meijaard & Nijman, 2000a). They are also found in heath and mixed dipterocarp forests (Jeffrey, 1982).

This primate is mostly arboreal only occasionally leaving the trees to cross open ground, or to pass through 'nipah' (*Nypa fruticans*) swamps (Bennett, 1986b). It occurs in areas of both wet and dry land, but always on acidic soils and near rivers

(Jeffrey, 1982). It has a home range of at least 9 km² (Bennett, 1986b) and its populations are scattered throughout Borneo (Meijaard & Nijman, 2000a). It rarely occurs in inland areas have been explained by limited food availability, shortage of essential resources, and competition with other primates (Bennett & Sebastian, 1988; Meijaard & Nijman, 2000a).

In the Malaysian State of Sarawak, Proboscis Monkey's habitats are: both mangrove and heath forest in Bako National Park and Samunsam Wild Life Sanctuary; and both mangrove and peat swamp forests in Maludam National Park and Ulu Sebuyau National Park. Salter and MacKenzie (1985) estimated that about one-third of the State population of Proboscis Monkey occupies deltaic mangrove. Their surveys showed that Proboscis Monkey does not use areas in the vicinity of active or recent intensive tree felling, and avoid regenerating areas even 10 or more years in age. They suggested that this is probably due to a combination of disturbance during the cutting phase, during which the monkeys apparently move out of the area, followed by a reluctance to move back post-logging (if they have survived in adjacent areas) due to loss of trees used for cover, food, sleeping and travel.

Nonetheless, Salter, MacKenzie, Nightingale, Aken and Chai (1985) classified habitat use by Proboscis Monkey into four categories in four locations (Bako, Samunsam, Maludam, and Deltaic sites) in the Malaysian State of Sarawak (Table

2.1). Of these habitat classifications, Proboscis Monkey mostly preferred the high forest types followed by the undisturbed tidal forests.

Table 2.1: Records of habitat use by Proboscis Monkey [Salter et al. (1985): 440]

Tidal forests:
Tree mangrove. Tree forests periodically inundated by tides;differentassociations dominated by *Sonneratia alba, Avicennia alba, Rhizophora mucronata, R. apiculata, Bruguieraparviflora.*
Nipa swamp. Stemless palm forests inundated at high tide only; nearly pure standsof *Nipa fruticans* with scattered emergent mangrove trees.
Nibong swamp. Driest of the tidal types; dominated by the palm *Oncospermatigillarium* withadmixtures of mangrove and riverain forest species.
High forests:
Riverain forest. High forest developed on seepage areas and river levees, with richspeciescomposition and irregular, closed canopy. Understory shrubs, palms, rattans.
Mixed dipterocarp/high kerangas forest. High forest with irregular canopy and frequent large emergents, and generally open understory; developed on well-drained sites.Species composition complex,but includes many Dipterocarpaceae.
Low forest and scrub:
Exposed cliffs. Scrub and herbaceous vegetation on exposed headlands and coastal cliffs.
Beach forest. Narrow bands of *Casuarina equisetifolia* and *Hibiscus tiliaceus* along sea beaches, above high tide mark.
Structurally altered habitat:
Selectively felled tidal forest. Tree mangrove and nipa swamp commercially or locally exploited for poles, firewood and/or thatch. Remaining stems separated by less than their crown diameters.
Clear-felled tidal forest. Tree mangrove in exploited woodchip license areas. All obligatory species removed, and remaining stems separated by more than their crown diameters. Other areas support dense pole-sized regeneration.
Logged peat swamp forest. Commercially or locally exploited peatswamp forest, with continuous 5-10 m high growth of trees and shrubs, and scattered remnant emergents.
Agricultural land. Areas under crops, or previously cleared and under secondary vegetation.
Urban land. Areas permanent human occupation, exclusive of cropland.

2.4.3 Social Behaviour

Proboscis Monkey has an organized set of social systems in that they live in harems, which are groups containing one male, several females and their offspring (Bennett & Gombek, 1993; Boonratana, 1993; Yeager, 1995). The average harem size is about nine (Bennett & Gombek, 1993) or ten animals (Macdonald, 1982; Yeager, 1993). They frequently come together at the river edges, especially in the evening (Bennett & Gombek, 1993; Matsuda, Tuuga, & Higashi, 2008; Yeager, 1995). Proboscis Monkey has a multi-level society (Matsuda, Tuuga, & Higashi, 2010; Murai, 2006) in which specific units associate at their sleeping sites within two separate bands in a manner similar to the fission-fusion patterns (Yeager, 1991b). One-male groups (group of one adult male with a number females and offspring) regularly associate with each other at sleeping sites with approximately two-thirds of their time spent in together (association with each other at sleeping sites) (Bennett & Sebastian, 1988; Yeager, 1990, 1991b). Sleeping groups vary, with nearly 60 (Macdonald, 1982) to 100 (Jeffrey, 1979) in several trees on both sides of the river, but groups of 10 to 18 are by far the most usual (Jeffrey, 1982). Proboscis Monkey chooses different sleeping sites regularly (Bernard & Hamzah, 2006; Bernard, Matsuda, Hanya, & Ahmad, 2011), which is likely to protect their group from predators (Matsuda, Kubo, Tuuga, & Higashi, 2010; Matsuda et al., 2008; Sha et al., 2008) such as pythons (Beavitt & Tuen, 2010) and crocodiles (Galdikas, 1985) .

Multi-level societal structure is also evidenced when several groups unite to cross a river to effectively avoid crocodile attack (Yeager, 1991a). The adult male play a leadership role within the group through their characteristic behaviour toward members of other groups or invaders; attacking, threatening, warning, watching, etc., (Bennett & Gombek, 1993; Kawabe & Mano, 1972). Proboscis Monkey is frequently found to move between different social groups, especially juvenile males and females, although they usually do not stay apart from their groups

(Bennett & Gombek, 1993). Females switch between harems at any time from before adolescence onwards, and they may change groups several times in their lives (Bennett & Gombek, 1993). Likewise, young males are rarely solitary but form all-male groups (Bennett & Sebastian, 1988; Boonratana, 2002; Yeager, 1990). Male Proboscis Monkey is forced to move out of the group in which it was born when it is only just old enough to fend for itself and team up with other males to form all-male groups (Bennett & Gombek, 1993). Bisexual groups are reported to be most stable, all-male groups are found to be less stable (Murai, 2004). Although all-male groups are more ephemeral (Kern, 1964; Macdonald, 1982; Salter et al., 1985) a number of them are reported to be in a stable group (Kawabe & Mano, 1972). All-male groups also associate with harems at the river edges, and often follow harems as they travel through the forest during the day (Bennett & Gombek, 1993). The variation in social structure of Proboscis Monkey is very difficult to explain because it may be influenced by food availability, predation threat, river width and water level, mating seasons (Matsuda et al., 2010), and difference in food resource distribution between sites (Macdonald, 1982).

2.4.4 Foraging Behaviour

There has been limited information on the foraging behaviour of Proboscis Monkey. Nevertheless there are a number of publications that provide some valuable information on, or related to, their feeding ecology, for example Boonratana (1993, 2000), Matsuda (2008), Matsuda et al. (2009a); Matsuda, Tuuga and Higashi (2009b), Salter et al. (1985) and Yeager (1989a). There are also a number of publications in relation to ecological and biological aspects of Proboscis Monkey in natural settings (Alikodra, 1997; Allen & Coolidge, 1940; Bennett, 1986b, 1988; Kawabe & Mano, 1972; Kern, 1964; Manansang et al., 2005; Meijaard & Nijman, 2000a; Sha et al., 2008; Soerianegara, Sastradipradja, Alikodra, & Bismark, 1994; Yeager, 1989b), but the key important aspect of conservation and management of these monkeys remains uncertain. For example, information on ranging behaviour (Boonratana, 2000; Matsuda et al., 2009b) is insufficient to understand feeding ecology of these monkeys. Although feeding activity as reported by Boonratana (2000) is one of the factors determining the ranging behaviour of these monkeys, the influence of food distribution, availability of food plants and canopy connectivity on foraging behaviour are still lacking, although he suggests that habitat types may likely determine distribution, and availability of food sources for Proboscis Monkey. Matsuda et al. (2009b) suggests that forest-based observation is a much better way for understanding the effect of environmental factors on ranging behaviour of Proboscis Monkey. However his analysis using this method is still insufficient to suggest that foraging behaviour of Proboscis Monkey is affected by food plant availability.

Foraging behaviour of Proboscis Monkey is still not much understood although Matsuda (2008) suggests that feeding activity is affected by monthly fruit availability. His analysis on feeding ecology and activity budgets of Proboscis

Monkey does not consider the effect of phenology of the food plants between wet and dry seasons, and the influence of food availability or low food abundance in different habitat types on feeding strategy. Furthermore, Yeager's (1989a); observations were recorded; does not provide a comprehensive understanding although some valuable information is discovered on feeding ecology of these monkeys. Even this observation method is limiting because feeding activities in the second half of day is not studied leading to inconclusive information on feeding ecology of these monkeys.

Proboscis Monkey is very selective feeders and groups move directly between food sources, sometimes covering large distances and even more than 600 m inland from the river edge (Bennett, 1988; Yeager, 1989a). Their foraging patterns have been shown to be influenced by environmental factors such as tides and topography of sites (Onuma, 2002; Salter et al., 1985) and also differ in relation to the height of trees (Boonratana, 1993; Ginting, 2009). Although ranging behaviour of Proboscis Monkey is affected by spatial and temporal distribution of food (Boonratana, 2000), little is known about the effects of seasonal change in food resources in different habitat types on their foraging behaviour. Moreover, despite feeding in a group (Bennett & Sebastian, 1988; Murai, 2004; Onuma, 2002; Sha et al., 2008), they feed on different types of food plants in different types of habitat (Matsuda et al., 2009a; Salter et al., 1985; Yeager, 1989a), and amount of food items they consume also differ according to daily activities they perform in different habitat types (Agoramoorthy & Hsu, 2005; Bismark, 2010).

Proboscis Monkey spends 19.5 per cent of activity budgets on feeding (Matsuda et al., 2009a) which occurs throughout the day (Bismark, 2010). In the Menanggul River, Sabah, the monkeys' diet consists of 65.9 per cent young leaves and 25.9 per cent fruits (Matsuda et al., 2009a). In contrast, feeding on young leaves in riverine and mangrove forests in Sukau and Abai in the Kinabatangan floodplain in Sabah accounted for 72.7 per cent and 49.7 per cent of their diet respectively (Boonratana, 1993). Moreover, young leaves constitute 95 per cent of Proboscis Monkey's diet as reported by Napier and Napier (1967) and 96.2 per cent by Bismark (2010). They prefer young leaves to mature leaves in their diet partly due to young leaves being higher quality food (Harris, 2006) which contain very high protein content (Waterman, 1984) and protein-to-fiber ratios (Chapman, Chapman, Naughton-Treves, Lawes, & McDowell, 2004; Wasserman & Chapman, 2003). While non-sweet fruit is also an important component of Probocis Monkey's diet, it avoids eating ripe fruit or pulpy fruit due to high sugar content (Bennett, 1988; Waterman, 1984).

Although the monkeys consume many types of food plant species, mangrove forest species (*Sonneratia alba, Avicennia alba, Bruguiera gymnorrhiza, Rhizophora* spp.) appear to be the single most important food plants (Salter et al., 1985). They prefer feeding on mangrove because it contains high protein and low fibre and is rich in minerals (Alikodra, 1997; Bennett, 1988; Hladik, 1978a). However, Proboscis Monkey is not only found foraging in mangrove forests (Kawabe & Mano, 1972; Kern, 1964) but also in riverine forests, peat swamp and freshwater swamp forests (Salter et al., 1985). Its preference for foraging in the coastal forests and along rivers suggest these areas may provide ample supply of salt and other minerals from the food plants as opposed to the interior of Borneo which may not have enough minerals to sustain a permanent population of this monkey (Bennett, 1988; Bennett & Sebastian, 1988).

On waking in the mornings, the first main event of the day is feeding. A post early morning feeding, rest of one to two hours is common and the animals spend the remainder of the morning and most of the afternoon alternating between feeding, resting and travelling (Bennett & Gombek, 1993). Despite some valuable information from previous studies, a comprehensive understanding of feeding behaviour is still lacking. In addition, information on the key important aspects of conservation and management of Proboscis Monkey is also insufficient for long-term conservation of these monkeys and their habitats that face ongoing threats from various sources including unsustainable land-use practices.

2.4.5 Conservation and Management

Proboscis Monkey is a primate of regional and international importance. Being a unique animal that is endemic to Borneo, Proboscis Monkey is the natural flagship in Borneo besides Orang Utan (*Pongo pygmaeus*) and other rare species. The status of Proboscis Monkey as endangered species is international recognition by the International Union for Conservation of Nature (IUCN, 2004) that its populations and habitats have been under threat. Regionally, conservation of this animal is fully committed to by the states in Borneo. In Malaysian State of Sarawak this monkey is protected under Wild Life Protection Ordinance 1998 and National Parks and Nature Reserves Ordinance 1998. However, long-term conservation of this animal and its habitat in Borneo are not guaranteed if unsustainable land-use practice and the disturbance and displacement of this species through various activities continue to occur within and in the vicinity of its natural habitat.

The major cause of the decline in the number of Proboscis Monkey has been habitat destruction (Bennett, 1988), and habitat loss and fragmentation (Bismark, 2010; Meijaard & Nijman, 2000b; Sha et al., 2008). This has been most evident in Kalimantan Indonesia, for example Pulau Kaget, which shows habitat loss and population decline (Meijaard & Nijman, 2000b). This problem is partly due to unsustainable land-use planning besides most developed areas in Borneo are on the lowland near coastal, swamp and riverine areas. In the Malaysian State of Sabah, coastal mangrove areas of Sandakan, Lahad Datu and Semporna are heavily developed leading to habitat loss and fragmentation (Sha et al., 2008). Although the monkeys have been recorded in remnants and fragmented forests (Jeffrey, 1982; Salter & MacKenzie, 1985; Salter et al., 1985), these forests may not guarantee their survival if isolated. Hunting is another pressure that leads to population decline in Kalimantan Indonesia (Meijaard & Nijman, 2000a) and the Malaysian State of Sabah (Sha et al., 2008). Proboscis Monkey is hunted as this monkey is considered as a pest (Bismark, 2010), for sport and meat (Sha et al., 2008). Hunting for this purpose does not happen in the Malaysian State of Sarawak and Brunei Darussalam because local people living near Proboscis Monkey's habitat do not eat the meat. As this monkey is totally protected in the Malaysian State of Sarawak, hunting for sport has been totally banned. In addition, some local people in the Malaysian State of Sarawak also realize that this animal is a tourism product (pers. comm. with park manager and village folks in Kampung Bako, Kampung Meludam and Kampung Pulau Salak). This understanding of the importance of Proboscis Monkey and its economic value is beneficial for the conservation of this monkey.

Apart from habitat destruction and fragmentation, illegal cutting of timber is another threat to Proboscis Monkey that diminishes the quality of its habitat although this activity is done in a small scale. Illegal cutting of timber is mostly done by local people, and sometimes occurs in protected areas because these areas contain quality timbers. Conversely, illegal logging with heavy machineries in protected areas is under control. However, as most Proboscis Monkey's habitats are near human settlements, encroachment by land developers into their habitats sometimes occurs. This indicates that the integrity of protected areas boundary has deteriorated and is not able to protect the areas themselves. Even good legislations are not effective to curtail illegal felling and encroachment in the Proboscis Monkey's protected habitats if law enforcement is poor. Despite landscape cover removal, mangrove and swamp reclamation and forest fire (Bismark, 2010; Bismark & Iskandar, 1996; Sha et al., 2008), populations of Proboscis Monkey and its habitats in some protected areas remain secure for long-term survival of this monkey provided that these protected areas remain intact and are not isolated.

Despite habitat loss, most land conversion for agriculture plantations in Borneo is distant from the monkey's habitats especially protected areas. This is because the main habitats, coastal and riverine mangrove land are not suitable for plantation except human settlements and shrimp farming (Meijaard & Nijman, 2000a; Sha et al., 2008). The intensive land conversion outside the protected habitats may also threaten the population density when remaining fragmented areas are poor in food resources. This is very critical decision for land planners and law makers on the priority between conservation of this primate and improvement of local economy. It is also a hard task for researchers to find out the solution for this problem through comprehensive research on this monkey especially population viability assessment and feeding ecology. Habitat conservation per se has not been enough to win the confidence of decision makers without empirical data that determines how much is enough for conservation of this monkey. Incorporating the best research findings into sustainable land-use planning and supported by political will and legislations would be a much better approach to long-term conservation of this monkey. This needs for comprehensive research that is timely and relevant to the conservation and management of the species has been the main goal of this study.

CHAPTER 3: STUDY AREA

This chapter provides a brief overview of Borneo and Sarawak. Borneo is an important region noted for the presence of a number of primate species, including the Proboscis Monkey, the primate which is the focus of study in this research. Malaysian State of Sarawak is the state within Borneo where the study sites for this research are located, which is therefore the most appropriate area to study this species. Bako National Park and Kuching Wetland National Park, which are the main study sites for this study of Proboscis Monkey, are presented in separate subheadings. Other study sites were surveyed for inclusion in Chapter 4.

3.1 OVERVIEW OF BORNEO AND SARAWAK

3.1.1 Borneo

Introduction

Borneo is the third largest island in the world with an area of 746,000 sq km (Wooster, Perry, & Zoumas, 2012). Geographically, this island is made up of three countries, namely Malaysia (shared between Sarawak and Sabah), Brunei Darussalam and Indonesia (Figure 3.1). The Indonesian provinces of Kalimantan that occupies the largest portion of Borneo's landmass, is divided into four administrative provinces of East, South, Central and West Kalimantan. Borneo is located at the equator, between 4° S to 7° N latitude and 108° E to 120° E longitude (Bontemps, Langner, & Defourny, 2012). The island is recognized as one of the world's 25 biodiversity hotspots (Myers, Mittermeier, Mittermeier, Da

Fonseca, & Kent, 2000; Raes, Roos, Slik, Van Loon, & Steege, 2009). It is home to 221 species of mammals, 620 species of birds, and 15,000 plant species, including over 150 species of Dipterocarp trees (WWF-Malaysia, 2012)

Figure 3.1: Map of Borneo (Source: ESRI)

Physical and Biological Environment

Borneo is a mountainous island, with a dorsal range rising to a maximum elevation of 4101 m at Mount Kinabalu in the far northwest (Wooster et al., 2012). Being the largest landmass in the Sunda Region, Borneo is covered by sedimentary shales (mostly inland) and sandstones (mostly coastal), deposited by past epicontinental seas (Ashton, 2010). Forest cover is dominated by one of the oldest equatorial rainforests in the world. Typically, hundreds of tree species coexist in a single hectare (Aiba, Kitayama, & Takyu, 2004) but these were associated with topography and canopy heterogeneity generated by forest regeneration or succession (Condit et al., 2000; Davies, Palmiotto, Ashton, Lee, & Lafrankie, 1998). Forest formation is characterized by the world's highest concentrations of Dipterocarp forest ecosystem (Wooster et al., 2012). The coastal and sub-coastal lowlands of Borneo are mostly covered by peat swamp forest at altitudes from sea level to about 50 m above (Wösten, Clymans, Page, Rieley, & Limin, 2008). There has been no study on the density of species per hectare in peat swamp forests per se. However, in one forest alone in peat swamp forests of Sarawak and Brunei as many as 185 species per hectare were found (Anderson, 1963). Moreover, Anderson (1963) found that the upper storey or upper canopy of peat swamp forests were predominated by species of Diterocarpaceae family in particular *Shorea* spp. with 98 to 395 trees per hectare. Heath forests or 'Kerangas' grow on extremely nutrient-poor and acid substrates. From the three categories of tree sizes (7.6 – 30.2 cm girth, 30.5 – 60.7 cm girth, ≥ 61 cm girth), Newbery (1991) found 3,585 tree species per hectare in Kerangas forests. These tree species, in descending order were mostly from the family of Dipterocarpaceae, Araucariaceae, Sapotaceae, Myrtaceae and Guttiferace, which combined to a total basal area of 2.5 m^2 per hectare. Freshwater swamps are found along rivers inland, and mangrove forests grow next to the shore line and cover coastal plains (Langner, Miettinen, & Siegert, 2007).

Climate

Borneo has a tropical climate with high temperatures. Whilst rainfall is frequent throughout the year, it mostly occurs between November and April (Dennis & Colfer, 2006). Rainfall patterns in terms of the total amount and its seasonal distribution show considerable variation (Harrison, 2001). The tendency for rainfall maxima to occur in the transition months is modified considerably by the positions of localities relative to the mountain ranges and coastline, and the monsoon winds (Walsh, 1996). A drier period is present between May and October (Langner et al., 2007) with often relatively light winds and only small annual temperature and humidity variations (Wooster et al., 2012). Similar rainfall patterns were also reported by Wooster et al. (2012), which clearly showed that wetter months occur between November and February, with drier months between May and August.

Land Use

Borneo is experiencing drastic landscape change due to population growth and economic expansion. Population pressure is expected to continue to escalate the rate of land clearance for agricultural production and other purposes (Vickers et al., 2010). In addition, a growing global demand for biodiesel, food-grain and cash crops such as rubber, sugar cane and coffee is also expected to increase agricultural expansion (Wertz-Kanounnikoff & Kongphan-Apirak, 2008). Population in Kalimantan in 2000 was 9.3 million with an average annual growth rate of 1.7 per cent (Oosternan & Wanabakti, 1999). Whilst the economy caters for the production and processing of the nation’s mining and energy reserves, total production of the Oil and Gas sector has declined due to pressure of other sectors that continue driving economic development. These sectors include coal, palm oil, steel, bauxite and timber. Palm oil is another robust revenue generator for the region, with oil palm plantations occupying 53 per cent of the total plantation area in Kalimantan (Ebeling & Heffernan, 2012). For Brunei Darussalam, the latest statistics available indicate a population of 414,400 with growth at an average rate of 1.8 per cent per annum (BEDB, 2012). The economy of Brunei has been dominated by the oil and gas industry for the past 80 years. Its household incomes are increasing rapidly, which have led to economic stabilization and reduced dependency on forests for daily subsistence and livelihoods. Thus the intimate connection between people and forest ecosystems has steadily weakened (Vickers et al., 2010). At present Brunei's rainforests cover 70 per cent of the total land area (BEDB, 2012).

In 2010 Sabah and Sarawak had populations of 3.2 million and 2.5 million respectively. The average growth of population for Sabah was 2.1 per cent per annum, whereas, Sarawak was 1.8 per cent per annum (SPU, 2011). Forestry has been a key economic driven for Sabah since late 1960 and early 1970s which saw a large growth of timber felling (Cleary & Eaton, 1995) and also the most important sector of Sabah's economy in 1980 (MID, 1982). Other sectors are mining, quarrying, petroleum and gas, fisheries and agriculture. In 2010 Sabah's economy were derived from petroleum or gas, agriculture, oil palm plantation, tourism, manufacturing, fisheries and manufacturing sectors (YSG, 2010). Lately agriculture and oil palm plantation have been the main focus to derive an economy for Sabah. Oil palm production increased from 5.2 million tones to 5.4 million tones in 2010 and hence 80,000 ha of land has been earmarked for the oil palm plantation (YSG, 2010). This was followed by the establishment of Sabah Development Corridor and Aquaculture Industrial Zones. The Federal Government has allocated RM110 million for several projects under the Sabah Development Corridor which include among other oil industry cluster project and agro-industrial precinct and integrated farming centre (MOF, 2012).

Sarawak's economy is mainly derived from service and manufacturing sectors which contribute 37.8 per cent and 26.4 per cent to gross domestic product (GDP) respectively. Other sectors are mining and quarrying (17.9 per cent), agriculture (15.6 per cent), and construction (2.3 per cent). In previous years, land conversion for agriculture took place rapidly with the expansion of oil palm plantations. The overall landscape change rate in Sarawak from 1990 to 2008 was 0.64 per cent per year, which was much lower compared to the rate evident in Borneo (Tsuyuki, Goh, Teo, Kamlun, & Phua, 2011).

Since the 1960's the landscape of Borneo has been converted into agricultural plots and plantations, especially in lowland areas (Wooster et al., 2012), degraded by fire (Langner et al., 2007), and fragmented due to other land uses, such as the development of infrastructure including expansion of townships, settlements, and roads. Forest cover of Borneo was estimated at between 73 per cent and 81 per cent in the late 1980's (Cleary & Lian, 1991), and at 50.4 per cent in 2000 (WWF-Germany, 2005). Annual forest cover lost as reported by WWF-Germany (2005) was approximately 1.2 per cent. In 2010, it was estimated that over 44 per cent of total forest area in Borneo was still covered by primary forests (WWF-Germany, 2005) which is consistent with data from Food and Agriculture Organisation (2011) for the same year. The change of Borneo's land cover fluctuated from 2000 to 2008 (Bontemps et al., 2012) due to some growing stocks from aforestation or forest plantation of both native and exotic species (Table 3.1). However natural forest cover decreased by 1.88 per cent annually.

Table 3.1: Yearly forest change rate in Borneo between 2000 and 2008

Period	Change rate (%)
2000–2001	1.5
2001–2002	1.6
2002–2003	1.3
2003–2004	2.6
2004–2005	1.3
2005–2006	2.7
2006–2007	1.8
2007–2008	2.2

(Source: Bontemps et al. (2012))

3.1.2 Sarawak

Introduction

Sarawak is the largest of the 13 states in the Federation of Malaysia. It is located at 0° 50' to 5' N latitude and 109° 36' to 115° 40' E longitude on the north-west coast of Borneo. It covers a total area of 124,449.5 sq km, or nearly 40 per cent of the island's landmass (SPU, 2011).

Physical and Biological Environment

Sarawak's landscape is characterized by coastal plains, valleys, rugged hills and steep mountains. It consists largely of relatively young, very deep sedimentary rocks that have been subjected to complex and localized folding, although more ancient formations, even pre-Permian, are found in the extreme west (Aken &

Kavanagh, 1982; Fitch, 1960). Approximately 23 per cent of the state's landmass is below the 30 m above sea level contour, forming a coastal plain of varying width, with a number of isolated outcrops. Above the 30 m contour, skeletal and podzolic soils predominate, being loamy sands to clays which are typically very shallow where the land is steep. Land above 1,500 m is characterized by montane forest formations, which constitute approximately 20 per cent of the state's landmass (Aken & Kavanagh, 1982). The formation of montane forests is concentrated in north-eastern part of Sarawak, particularly the Kelabit Highlands, and the state's highest peak, Gunung (Mt.) Murud, which rises to 2,425 m, and the nearby, Gunung (Mt.) Mulu (2,376 m). The major forest types are mixed Dipterocarp forests, peat swamp forests, mangrove forests, and secondary forests (Figure 3.2). Total mangrove area in Sarawak is approximately 127,736 ha, or about 1 per cent of the Sarawak's landmass (Morni, Mohammad, & Yusop, 2008).

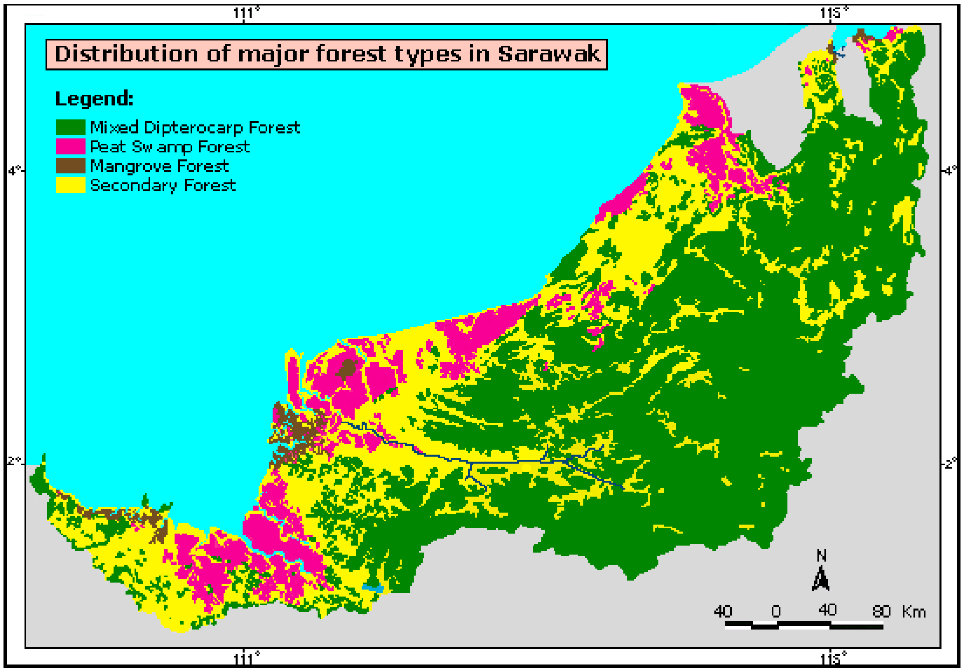


Figure 3.2: Major forest types in Sarawak (Source: FDS (2012b))

Climate

Sarawak has one of the most non-seasonal climates anywhere in the world, with uniform moderately high temperatures, high humidity and heavy all-year-round rainfall (Hazebroek & Morhsidi, 2000; Hunt & Premathilake, 2011). It has a hot and humid equatorial monsoon climate with daily temperature variations between 22°C at night to 33°C in the afternoon, and mean annual rainfall ranging from 2000 mm to more than 7000 mm (Hazebroek & Morshidi, 2000). The heaviest rainfall occurs during the north-east monsoon from November to March and dry periods during south-west monsoon from June to August (Hunt & Premathilake, 2011). The arrival and duration of each season varies from year to year (Stephens & Rose, 2005).

Land Use

The land tenure in Sarawak is based on the 1958 Land Code drawn up by the colonial government, which categorizes the land into: Reserve Land, Mixed Zone Land, Native Area Land and Interior Area Land, including Native Customary Land. Reserve Land which is held by the State Government mainly consists of Permanent Forest Estates comprising three sub-categories: Forest Reserve, Protected Forest and Communal Forest (these three sub-categories of forests are stated in the Forest Ordinance, 1958). Totally Protected Area is mainly established from this category, whereas, native shifting cultivators mainly occupy Native Customary Land (Native Customary Rights) and Native Area Land, located along rivers and in the coastal zone respectively. The proportions of these categories of land, however, have always changed because different land-uses have been regazetted as Mixed Zone Land to allow conversion to tree crop plantations (Hansen, 2005) or other purposes.

About 84 per cent or 10.4 million ha of Sarawak's total land area is covered by forests as well as secondary forests (FDS, 2012b). The remaining 2.4 million ha are under settlements, towns, commercial agricultural crop cultivation and native customary rights land (FDS, 2012b). Most of these forms of land use (Table 3.2) have taken place on lowland areas, including lands fragmented or under-utilized by shifting cultivation or forest fallow cultivation. Secondary forests are naturally established after abandonment of 10 years or more by shifting cultivators. The extent of urban areas, commercial agriculture and shifting cultivation has changed much Sarawak's land-use patterns.

Table 3.2: Land use classification

Classification	Hectares	Per cent
Forest:	10,411,290	84.1
Forested	8,608,164	69.5
Secondary Forest	1,803,126	14.6
Agriculture	1,659,045	13.4
Settlement	259,203	2.1
Water Body	52,141	0.4
Total	12,381,679	100.0

(Source: Forest Department Sarawak (2012b))

Since the 1920s Sarawak has invested in planted forests and planted both native and exotic species on the degraded or under-utilized land caused by shifting cultivation. Up to the end of 2000, despite financial constraints the State Government of Sarawak had planted 23,096 ha. In 2009, a total of 42 Licence for Planted Forests (LPFs) have been issued covering plantable areas of approximately 1.3 million hectares (FDS, 2012d).

Apart from the above land-uses, about 1 million ha (approx 8% of landmass) are targeted to be gazetted as Totally Protected Area (TPA). Totally Protected Area is areas that have been gazetted as national parks, nature reserves and wildlife sanctuaries. These Totally Protected Area aims to protect and preserve Sarawak's biodiversity, and become refuges for Totally Protected Species of wildlife, such as the Orang Utan and Proboscis Monkey, under Wild Life Protection Ordinance 1998.

Currently, Sarawak has 25 national parks, five nature reserves and four wildlife sanctuaries (Appendix 1) which cover a combined 534,506.46 ha of land area and 206,344.00 ha of water bodies (FDS, 2012a). Under the Heart of Borneo (HoB) Initiatives, Sarawak is one of two states in East Malaysia that has committed to conserve and manage an area of 22 million ha of tropical rainforests that transverse the borders of the three countries on the island of Borneo. This conservation initiative is trans-boundary cooperation between Malaysia, Indonesia, and Brunei Darussalam which was officially launched in Brazil on 27 March 2006. The joint declaration was signed on 12 February 2007 in Bali. A key statement in the Declaration is:

> *With one conservation vision and with a view to promote people's welfare, we will cooperate in ensuring the effective management of forest resources and conservation of a network of protected areas, productive forests and other sustainable land-uses within an area which the three respective countries will designate as the "Heart of Borneo (HoB)", thereby maintaining Bornean natural heritage for the benefit of present and future generations, with full respect to each country's sovereignty and territorial boundaries, and also without prejudice to the ongoing negotiations on land boundary demarcation.*
>
> *(ECG (2007): 19)*

3.2 BAKO NATIONAL PARK

Introduction

Bako National Park was gazetted in 1957 as a Totally Protected Area under the National Parks and Nature Reserves Ordinance, 1998. Sarawak's oldest national park, it is a small public park covering an area of 2,727 ha, which is situated at the forested cape of Muara Tebas at 1° 52' N, 110° 06' E and about 30 km north of Kuching City.

Physical and Biological Environment

Geologically, Bako National Park is mainly sedimentary rock of the plateau sandstone formation. Sandstone in this area contains a great diversity of sedimentary structures including large scale trough and tabular cross beds, ripple marks and convolute laminations. The coastlines exhibit beautiful landscape features such as sea stacks, sea notches, abrasion platforms, platforms, pot holes, *tafoni* and various other honeycomb structures (UKM, 2008). The park contains a relatively low-stature, coastal forest on nutrient-poor sandy soils with a high density of small trees or small canopy and sub-canopy trees. Generally, the forest types are categorized into: beach forest, mangrove forest, cliff vegetation, mixed dipterocarp forest, peat swamp forest, riverine forest, heath or Kerangas forest, and Kerangas or scrubland on the plateau. These forest types provide a number of patchy habitats for wildlife species, especially Proboscis Monkey, Silvered Leaf

Monkey (*Trachypithecus cristatus*), Long-tailed Macaque (*Macaca fascicularis*) and Bearded Pig (*Sus barbatus*) (Budeng, 2004).

Climate

The Park's strategic location at the tip of Muara Tebas, combined with its isolation from the influence of Borneo's remaining landmass, has created an obviously seasonal climate. Its climate is humid tropical with temperatures ranging between 20°C and 32°C and annual rainfall from 2006 to 2010 was 3642 mm (DID, 2011). Most rainfall occurs during the north-east monsoon from November to February. Rainfall station record at the park headquarters indicates that November to February are consistently wetter months (Figure 3.3). Monthly average rainfall during these wetter months was 562 mm. During a distinct drier period, from May to August, average monthly rainfall was 124 mm. Mean historical monthly rainfall and temperature produced by World Bank (2012) also showed the seasonality of climate in Bako National Park (Figure 3.4). This seasonality of climate is consistent with that reported earlier by Good (1988), and by Hazebroek and Morshidi (2000).

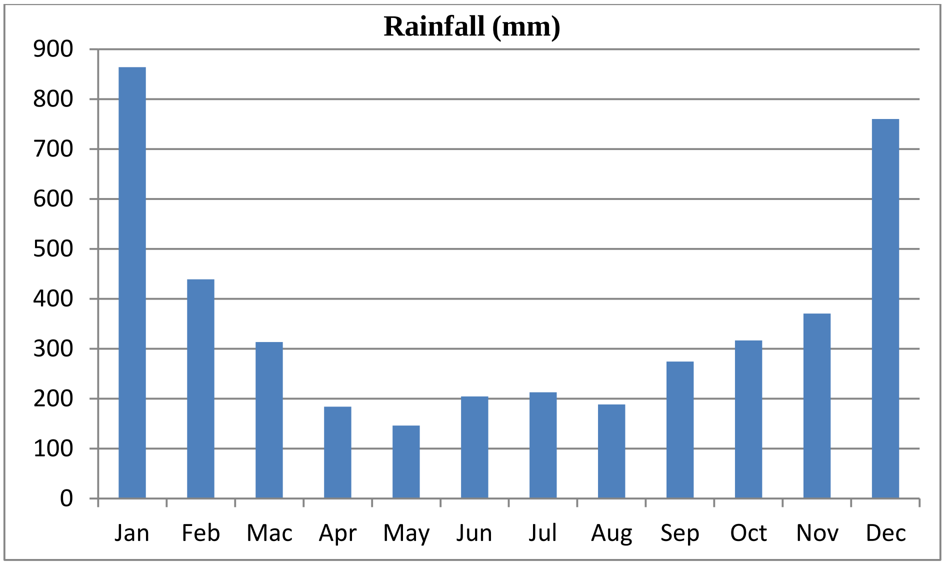


Figure 3.3: Bako National Park: monthly rainfall (Source: Drainage and Irrigation Department (2011))

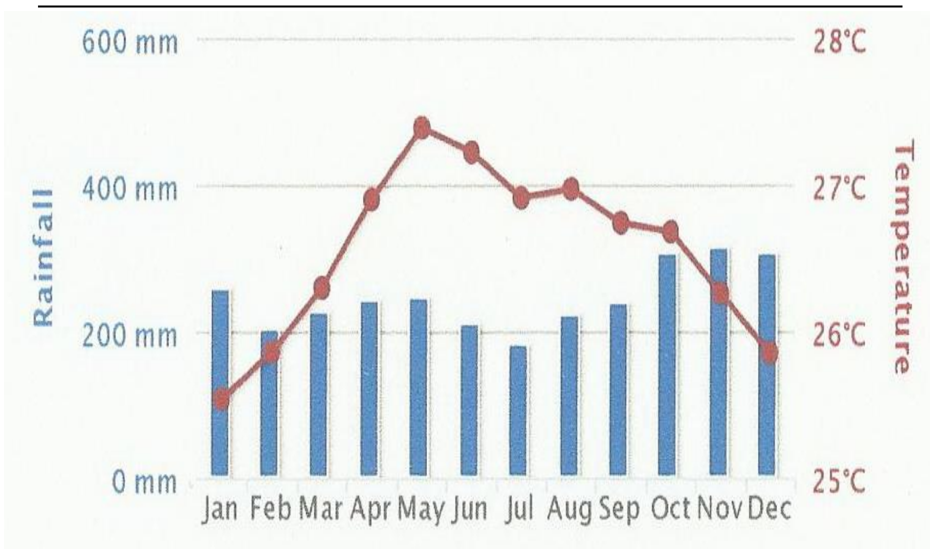


Figure 3.4: Mean historical monthly rainfall and temperature in Bako National Park from 1900-2009 (Source: World Bank (2012))

Land Use

Bako National Park is very secluded and can only be reached by water transport. The park is established for proctection and conservation of fauna and flora especially Proboscis Monkey and other wilidlife and seven types of vegetation. Currently, the park has been developed to cater for tourism needs by providing tourism acommodation and other facilities. Electricity is sourced directly from SESCO through underground cables, and water supply is provided by the Kuching Water Board in Kuching City. The park is divided into three zones: tourism zone, accommodation zone, and wilderness zone. Currently the park provides eighteen trails for tourists to explore the park.

Whilst the frequency of disturbances such as illegal hunting at park boundaries is quite low, these activities continue to occur. The proximity of the southern part of the park boundary to a public road (approx. 2 km) is a major contributing factor. Other anthropogenic activities such as farming and fish ponds near boundaries would have some effects in accelerating forest change. The effect of seasonal change in climate on the forest in Bako National Park has been reported earlier by Primack and Hall (1992). This effect was evidenced by slow recruitment among small tree species to recover from catastrophic disturbance (possibly severe drought) that killed some larger tree species. This evidence suggested that the small changes in climate had affected timing and intensity of flowering and seeding events, and subsequently brought negative impacts on forest biodiversity and ecosystem services. Therefore risk of climate-induced extinction would increase due to the reduction in species mobility (Vickers et al., 2010) if forest fragmentation near the park boundary continued to take place.

The sand dredging at the mouth of Sg. Bako which was in operation over a number of years has not been in operation during the last two years (2011-2012). This may cause of sea bed erosion and sedimentation. Sedimentation has been an environmental phenomenon that changes mangrove habitat (Saad, 1996) and was believed to be among the factors contributing to the death of mangrove trees (Ellis, Nicholls, Craggs, Hofstra, & Hewitt, 2004; Ellison, 1999). This may also cause of mangroves dying at Teluk Assam in Bako National Park.

Conservation Significance

Bako National Park is the only national park of Sarawak that provides proper tourism facilities for the public to see Proboscis Monkey in the wild. Maludam National Park and Kuching Wetland National Park, which are also home to Proboscis Monkey, have no proper tourism facilities in place as yet for the public to access and enjoy the areas.

Proboscis Monkey is a key tourism drawcard for Bako National Park. An early report by Salter and MacKenzie (1981) estimated that Proboscis Monkey in the park numbered between 106 and 144 individuals, however data for the period prior to the establishment of the park is unavailable to gauge a population trend. This data was based on foot surveys along existing trails and along the landward edges of mangrove areas; searches were non-systematic but were spaced and timed to obtain a representative coverage of the park area (Salter & MacKenzie, 1985). Using strip census, Zaini etal. (2004) estimated that the number of Proboscis Monkey in the park was 275 individuals. At present, this data is being used officially, although in the following year Zaini and Ilias (2005) estimated only 111 individuals. The discrepancy between survey results occurred due to technique and areas covered by the study. Notwithstanding the above, the survival of *N. larvatus* is not fully assured because the national park area is too small at present to guarantee that it would contain a viable population if isolated by land-use change (Bennett, 1986b).

3.3 KUCHING WETLAND NATIONAL PARK

Introduction

Kuching Wetland National Park was formerly known as Sarawak Mangrove Forest Reserve. The park is located approximately 15 km from Kuching City at 1°40' 59" to 1° 41' 18" N latitude and 110° 12' 16" to 110° 16' 20" E longitude. It was gazetted in 2002 as a Totally Protected Area under the National Parks and Nature Reserves Ordinance, 1998 (Chap.27) covering an area of 6,610 ha.

Physical and Biological Environment

The park is predominantly a good representation of saline deltaic mangrove system (FDS, 2012c). With an altitude of less than 5 m above sea level, the park is characterized by an extensive network of estuarine waterways interconnecting the rivers of Sibu Laut and Salak, their tributaries and other creeks. It is almost entirely flat, being flooded at high tide with sea water in most areas (Bennett & Reynolds, 1993). The landscape of the park is covered by three major types of forests. These forest types are Sonneratia forests, mixed-mangrove forests, and heath forests. Sonneratia forests are dominated by *Sonneratia alba* (FDS, 2010a) and whilst mostly found on the sandy mud-flats, distribution is not extensive. In certain circumstance, Sonneratia interspersed with Avicennia forms a forest strip by an average of 25 m in width. *Sonneratia alba* colonizes newly formed silty mudflats and stabilizes the riverbanks and coastlines.

Climate

Kuching Wetland National Park also experiences seasonal climate similar to that of Bako National Park. Its climate is humid tropical with temperatures ranging between 20°C and 32°C. Its average annual rainfall, as recorded by two rainfall stations at Rampangi and Semariang, is 4155 mm. The rainfall record from these two stations showed that November to February were wetter months with average rainfall of 583 mm (Figure 3.5). The drier months were from May to August with average rainfall of 189 mm (FDS, 2010a). The historical rainfall and temperature data produced by World Bank (2012) also showed that November to February were the wetter months, and May to August were the drier months (Figure 3.6).

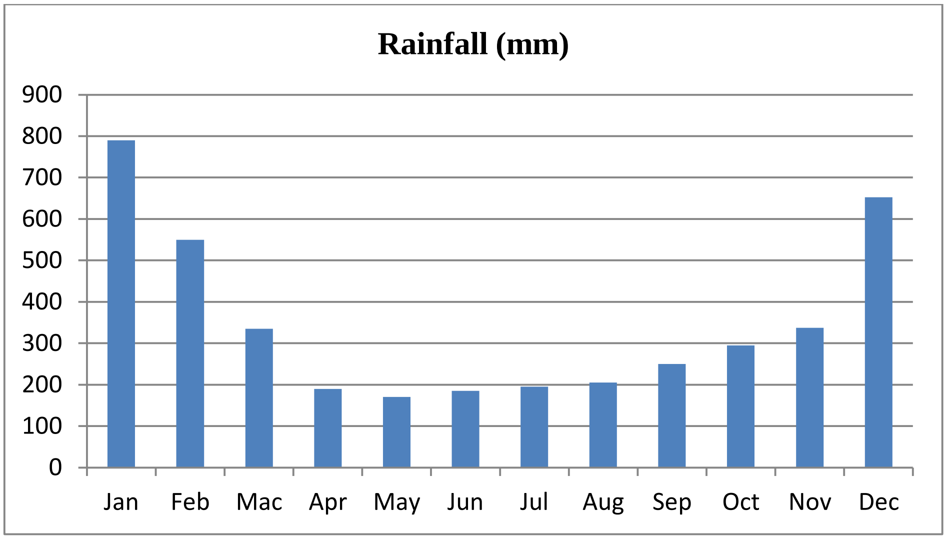


Figure 3.5: Kuching Wetland National Park: monthly rainfall (Source: Drainage and Irrigation Department, (2011))

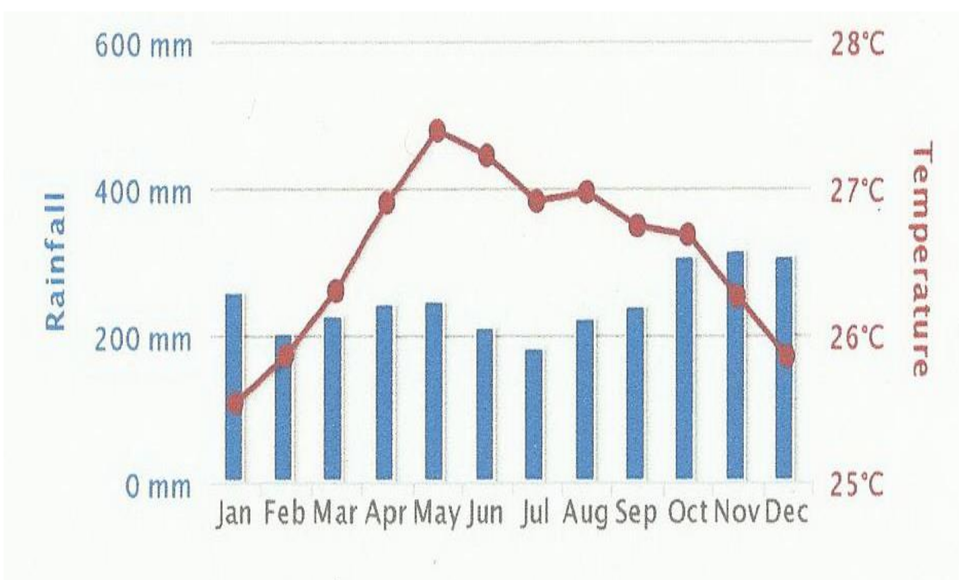


Figure 3.6: Mean historical monthly rainfall and temperature in Kuching Wetland National Parkfrom 1900-2009 (Source: World Bank (2012))

Land Use

Kuching Wetland National Park is surrounded by traditional settlements: Kampung Sibu Laut on the west, Kampung Salak on the east, and Kampung Semariang Batu on the south-east. Telaga Air settlement, which is the closest access point to the park by road, lies to the north-west. Sg. Salak on the east and Sg. Sibu on the west form the boundary of the park and are the traditional waterways for the local communities living along or close to the park boundary. The main economic activities of the wetland communities are sedentary agriculture and fishing (Fui, Shuib, & Edman, 2011). On the southernmost boundary, a new housing estate has been completed. A private oil palm small holding is operating along the southern boundary, with aquaculture farms on the north-west boundary, and stone quarrying in operation on Pulau Salak on the eastern boundary (FDS, 2010a). A flood mitigation channel flows through the park on the south-eastern boundary (Minton, Peter, & Tuen, 2011). The extraction of mangrove poles by local people, although no longer permitted, is still occurring but is not rampant. Mangrove poles are used as building materials and in the production of charcoal (Bennett & Reynolds, 1993), but the demand is inconsistent and has decreased due to competition with alternatives (Chai & Lai, 1984). Apart from the above said land-uses, the park also is a popular site for nature or wildlife viewing enthusiasts. Private tour companies regularly operate wildlife boat cruises in the park. As the park is not open yet to the public, unmanaged ecotourism activities within the park may bring some negative effects to wildlife behaviour, especially Proboscis Monkey.

Conservation Significance

The park is an important spawning and nursery ground for fish and prawn species, as well as an important nursery area for the estuarine crocodile (*Crocodylus porosus*). The park is not only animportant site for viewing Lesser Adjutant (*Leptoptilos javanicus*) and Irrawaddy Dolphin (*Orcaella brevirostris*), but also home to three species of primates, namely Proboscis Monkey, Silvered Langur (*Trachypithecus cristata*) and Long-tailed Macaque (FDS, 2010a). According to Bennett and Reynolds (1993) the area is one of the only remaining refuges for mangrove flora and fauna in Sarawak. It is the last remaining large area of relatively intact mangrove near to the Kuching City. The mangroves supported marine fisheries worth US$21.1 million p.a. and up to 3000 jobs (Bennett & Reynolds, 1993).

In 2005 the park received international recognition when it became the first area in Sarawak to be listed under the Ramsar Convention. Ramsar is named after the Iranian city of Ramsar in 1971 where the inter-governmental treaty, the Convention on Wetlands of International Importance (the Ramsar Convention) was adopted. The treaty came into force in 1975, and provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources (COP, 2009). Malaysia became a signatory of the

Ramsar Convention in 1994 (Chong, 2006) and has to date designated six Ramsar sites including Kuching Wetland National Park (Table 3.3).

Table 3.3: List of Ramsar sites in Malaysia

Ramsar sites	Date of designation	Region	Area (ha)
Kuching Wetland National Park	08/11/05	Sarawak	6,610
Lower Kinabatangan-Segama Wetland	28/10/08	Sabah	78,803
Pulau Kukup	31/01/03	Johor	647
Sungai Pulai	31/01/03	Johor	9,126
Tanjung Piai	31/01/03	Johor	526
Tasek Bera	10/11/94	Pahang	38,446

Kuching Wetland National Park is selected by the Contracting Parties, or member states, for designation under the Convention by reference to the Criteria for Identifying Wetlands of International Importance (COP, 1999). The specific Ramsar criteria which the Kuching Wetland National Park was selected for are:

- Criterion 1: The site is a particularly good representative example of a natural coastal mangrove system, characteristic of the Borneo biogeographical region (Udvardy, 1975),
- Criterion 2: The site supports the Proboscis Monkey *Nasalis larvatus* - listed in Appendix I of the Convention on International Trade in Endangered Species (CITES) and 'Endangered' in the 2004 IUCN Red List, Lesser Adjutant *Leptoptilos javanicus* - listed in the 2004 IUCN Red List as 'Vulnerable', and Griffith's Silver Leaf Monkey/Langur *Trachypithecus villosus* (listed as "Data Deficient" in the IUCN (2004) Red List),

- Criterion 4: The site is of special value as a nursery area for the Estuarine Crocodile (*Crocodylus porosus*), and
- Criterion 8: The site is an important spawning and nursery ground for fish and prawn species.

CHAPTER 4: PROBOSCIS MONKEY HABITAT ASSESSMENT

4.1 INTRODUCTION

This chapter presents habitat assessment of primates, in particular Proboscis Monkey, which is based on major ecosystems and vegetation types with the support of relevant literatures. The chapter also outlines some reasons for undertaking habitat assessment in this study. The forest structure of Proboscis Monkey's habitats within the study sites was investigated. Factors previously identified in relevant literature as affecting habitat use by Proboscis Monkey were used to assess the monkeys' habitats in this study, and their differences were compared with the support of satellite imagery. The summary statistics of variables for each habitat type, and the distribution of D.B.H. (diameter breast height) classes of the stands derived from each secondary site location, are presented according to each habitat type. The density of each plant species and the stand profiles are also highlighted. All these and other findings permit detailed discussion of the quality of each major habitat type. In the conclusion, the summary of habitat assessment and the relative roles of the different types of forests are discussed, including the threatening processes that affect the forest structure and floristic plant variety in the study sites.

4.1.1 Habitat Assessment of Primates

Globally, natural wildlife habitat has become increasingly reduced, isolated and fragmented, which has lead to the extinction of certain species of wildlife. As natural habitat is a pristine natural environment that supports long-term survival of wildlife, assessing the current status of wildlife habitat is of paramount importance. Primate habitat has not been spared from the effects of anthropogenic land-use. It was reported that more than half of the world's primate species are being threatened by extinction due to unsustainable land-use practices (Chapman & Peres, 2001). This situation has triggered various studies on the habitat assessments of a few primate species to determine the level of habitat suitability required for species survival. In the Amazon and San-Martin, Peru, Buckingham and Shanee (2009) have classified the habitat suitability for Yellow-tailed Woolly Monkey (*Oreonax flavicauda*) based on land-use and topography both within and outside the existing protected areas network. Protected areas such as national parks have ample protection system however intrinsic disturbances sometimes occur in addition to the mobility of primates that forage outside the parks. Ecologically, extrinsic disturbance outside the protected areas network inflicts much pressure to certain species of primates, particularly when they occur within fragmented and isolated habitats. Moreover, habitat assessment of primates in isolated forest fragments has attracted much attention due partly to uncertainty surrounding their actual status and conservation opportunities. This habitat assessment is mostly done for rare and endangered species (Shanee, Shanee, &

Maldonado, 2007) as a numberof existing protected areas of the world have been of inadequate capacity and integrity to provide quality foraging areas.

Although some primate species are relatively tolerant to habitat disturbance, a few, especially arboreal primates, are very sensitive to transformation and fragmentation of natural landscape (Arroyo-Rodríguez & Dias, 2010). This is because arboreal primates require a high level of connectivity for them to move from tree and forest patch to another. Conversely, the modified habitat matrix, and subdivision of landscape patches (Fischer & Lindenmayer, 2007) limit the mobility of arboreal primates. Given this, anthropogenic pressure has made the habitat assessment study more challenging as it involves various factors that become threatening processes to the existence of primates. Consequently, landscape cover and patches are among the most prominent factors in habitat assessment study for arboreal primates. For example, in the study of the Mexican Mantled Howler Monkey (*Alouatta palliata mexicana*), habitat assessment involves all landscape attributes as not only the amount of forest cover, but also patch configuration, become determining factors in designing management strategy for conservation of this primate (Arroyo-Rodríguez et al., 2008). Other habitat assessment studies suggest that habitat structure influences viability of certain primate taxa in fragmented habitat: for example Boubli, Couto-Santos and Mourthe (2010); Boubli, Schwarzkopf and Rylands (1989); and Warner (2002). In Brazilian Atlantic Forest, Woolly Spider Monkeys (*Brachyteles arachnoids*) not only successfully persist in fragmented habitat (Mendes et al., 2005; Strier, 2000), but these monkeys have specific habitat requirements that relate to habitat characteristics (Boubli et al., 2010).

Despite habitat characteristics differing slightly according to habitat types, preferred habitat relates to preferred foraging areas where primates can find sufficient and suitable living needs for survival. Even in secondary forests, certain primate species can tolerate less appropriate habitat and survive. The most favourable quality of habitat for primates should provide, among other factors, good connectivity, food plants, trees which provide resting sites, and be free from predation for them to survive, unless there is an ongoing natural and/or human disturbance that may displace the primates. However, habitat may change over time which may influence the way the primates adapt to their varying ecosystem. This has been demonstrated by Titi Monkey (*Callicebus coimbrai*) in Fazenda Trapsa, Brazil, where their occupancy varieswithin different habitat types. Assessment carried out on mature, secondary and anthropogenic category of habitats shows Titi Monkey to be more abundant in the small fragments, and able to survive in fragments of secondary forest (Chagas & Ferrari, 2010).

Habitat assessment of arboreal monkeys is of both ecological and biological importance, partly due to disturbances that alter landscape structure. Intact landscape cover with the quality of habitat structure and connectivity prevent the need for a higher expenditure of energy for locomotion as a consequence of vertical travel when canopy is sparsely connected (da Silva Junior et al., 2009). Therefore, forest structure has been a common variable in habitat assessment of arboreal monkeys. Table 4.1 below presents a summary of preferred habitat characteristics of primates from a number of selected studies on habitat assessment.

Table 4.1: Summary of preferred habitat characteristics of primates

Primate species	Preferred habitat	Study sites
Yellow-tailed Woolly Monkey (*Oreonax flavicauda*)	Forested area between 1,800 and 2,200 m above sea level is suitablehabitat.	North-eastern Peru (Buckingham & Shanee, 2009)
Spider Monkey (*Atele geoffroxi*) Howler Monkey (*Alouatta palliata*)	Wider area of tropical lowland and temperate forest is mostly preferred. Tropical lowland and temperate forest is mostly preferred.	Southern Mexico (Ortiz-Martínez, Rico-Gray, & Martínez-Meyer, 2008)
Black Howler Monkey (*Alouatta pigra*)	Occurs in many forest types from lowlands up to 2,705 m above sea level.	Eastern Guatemala (Baumgarten & Bruce Williamson, 2007)
Muriquis (*Brachytel hypoxanthus*) – northern part Muriquis (*Brachyteles arachnoids*) – southern part	A much drier habitat at lower altitude (mean: 681 m) with slope ridges, and higher density of liana and emergent trees. Habitat of higher altitude (mean: 1165 m) with steeper terrain. Habitat with greater canopy height, good connectivity, higher canopy density, higher density of mid story, and density of epiphytes are mostly preferred compared to Muriquis in the northern part.	Brazilian Atlantic Forest (Boubli et al., 2010)
Callicebus xanthosternos *Callitrhix jacchus*	Mature forest, larger and better preserved fragments at lower and higher forest strata. Mature and secondary forest at lower forest strata.	Brazilian Atlantic Forest (Chagas & Ferrari, 2010)

4.1.2 Previous Habitat Assessment of Proboscis Monkey

Previous research on Proboscis Monkey in Borneo has focused more on ecology and behaviour of this primate; for example Matsuda (2008), Matsuda, Tuuga and Bernard (2010), Matsuda et al. (2009b), in Sabah; and Bennett (1986b, 1988), Bennett and Sebastian (1988), in Sarawak. Additionally, a number of previous studies mostly focused on habitat use of Proboscis Monkey intrinsically, rather than habitat assessment (Salter & MacKenzie, 1981, 1985; Salter et al., 1985). Among the habitat use studies, Salter et al. (1985) categorized four types of habitat use by Proboscis Monkey, however since then no detailed study has been conducted on habitat use by Proboscis Monkey in Sarawak. In addition, population and habitat surveys have not been carried out for the last ten years. One of the reasons for the lack of recent surveys is that Proboscis Monkey is well known within the existing national parks of Sarawak which are perceived to provide adequate protection to this primate.

While very limited studies have been carried out on Proboscis Monkey in Brunei, a number of studies in Sabah revealed isolated populations of Proboscis Monkey at risk of extinction due to fragmented habitats. Most of the studies in Sabah were conducted at Kinabatangan and its tributaries; for example, Sha et al. (2008), whose study took place in riverine mangrove and peat swamp forest habitat. In Kalimantan, Indonesia, habitat use studies have placed more emphasis on the impact of land-use on the population density of this monkey. The situation on

Pulau Kaget is a prime example of the link between loss of quality habitat and declining populations of Proboscis Monkey (Meijaard & Nijman, 2000b). A similar study by Bismark (2010) further confirmed that populations of Proboscis Monkey are in decline not only due to habitat degradation, but also as a result of this monkey being viewed as a pest in Kalimantan, Indonesia.

4.1.3 Proboscis Monkey Habitat Assessment Study

This study was conducted to assess the current status of Proboscis Monkey's habitats in the Malaysian State of Sarawak. These habitats are well known for the occurrence of Proboscis Monkey based on both previous research and information from local inhabitants. The primary study sites for this study were Bako National Park, Kuching Wetland National Park, Maludam National Park, Selabat mangroves and Bako High School mangroves. While there were a number of previous and ongoing studies on Proboscis Monkey conducted in Bako National Park and Kuching Wetland National Park, the most recent survey in Maludam National Park was conducted in March 2002 (Hon & Gumal, 2004). Proboscis Monkey is well protected in these three national parks. However, Selabat mangroves and Bako High School mangroves are outside protected areas and based on local information, the monkeys do occur in these two areas and their populations are unknown. These five primary sites represent six types of Proboscis Monkey's habitats which are categorized as follows.

a. Medium closed heath forest – Bako National Park

b. Low closed heath forest – Pulau Lakei – Bako National Park
c. Swamp forest or Flooded forest – Kuching Wetland National Park
d. Swamp forest or Peat moss forest – Maludam National Park
e. Coastal mangrove – Selabat and Bako National Park
f. Riverine mangrove – Selabat, Bako High School, and Kuching Wetland National Park

There was no change on Proboscis Monkey's habitat in Bako National Park except the small patch of mangrove at Teluk Assam which was dying since this study was conducted in 2013. A landscape matrix was evident outside the park boundary due to private land clearing. In Kuching Wetland National Park, illegal felling of mangrove by local people for charcoal is ongoing, as well as felling of other trees for domestic use. Illegal felling by local people for domestic use also occurs in Maludam National Park, as does a series of linear disturbances across the river created by the encroachment of heavy machinery from the nearby agricultural plantation. There was also an indication of felling of mangrove in Selabat mangrove whereas Bako High School mangrove is a small isolated patch of mangrove which is surrounded by land clearing. Specifically, the preferred objective and sub-objectives of this study are:

1. To investigate whether there is any difference on the status of Proboscis Monkey's habitats inside and outside of protected areas.

1.1 To examine the prominent characteristics and the forest structure of Proboscis Monkey's habitats.

1.2 To investigate the changes in habitat attributes that might occur in these habitat types due to disturbances.

4.2 METHODS

The method was designed according to habitat characteristics, and parameters were recorded based on known habitat use of Proboscis Monkey. Sightings of wildlife was undertaken in accordance with survey and census methods for primate (Ross & Reeve, 2003). Sattelite imagery of the study areas was used to compare the landscape patterns between 2004 and 2013 in each study sites. Using 1:50 000 scale maps, forests, water bodies including rivers, streams, lakes and other relevant features were digitized and incorporated into a Geographical Information System (GIS) layers in a Windows programmes, Arc View (Dawson, Hornby & Hilton, 2002). Informal incidental observations on landscape disturbance outside or beyond the boundaries of the study areas in the form of detailed additional notes were also undertaken.

4.2.1 Habitat Assessment Survey Design

The list of Proboscis Monkey's locations in Borneo was prepared based on a number of previous research studies prior to the selection of sites for habitat assessment study, however the current status of some locations was unknown

(Appendix 2). Sarawak was chosen as the study site due to time constraints and ease of access. Gaining permission to carry out a survey in Kalimantan would be very difficult. Among the Proboscis Monkey's habitats in Sarawak, primary site locations were identified in both Kuching and Betong Divisions. Identification of these primary site locations was based on habitat characteristics and occurrence of Proboscis Monkey. Proboscis Monkey's habitats in the study sites were categorized into mangrove forests (Table 4.2), swamp forests (Table 4.3) and heath forests (Table 4.4). Within each primary site location, secondary site locations were identified to lay out sampling units. These secondary site locations were chosen based on the following factors.

a. Location of previous studies on Proboscis Monkey.
b. Sightings of Proboscis Monkey.
c. Accessibility or convenience of access, for example using existing tracks because of density of forest and flooded terrain.
d. Avoiding edge effects, in particular disturbance or intrusion by human activities.
e. Avoiding pseudo replication to ensure independence of samples by spacing of transects and using fishbone layout.

Table 4.2: Ecosystem categorization in mangrove forest

Category	Characteristics	Subcategory	Characteristics	Primary sites	Secondary sites	Sampling unit	Plot design
Mangrove	1.tidal 2. salt intrusion	**Coastal**	1. Species uniformity 2. Sea/coastline visible	Selabat	1	3	Circular (16m) 200 m²
				Bako NP	2	15	Quadrat (20x20m) 400 m²
		Riverine	1. Mixed species 2. At least 100m from coast	Selabat	2	2	Circular (16m) 200 m²
				Bako High School	1	1	Linear (40 x 5m) 200 m²
				Kuching Wetland NP	5	25	Quadrat (20x20m) 400 m²
				4	**11**	**46**	**Circular = 5** **Linear = 1** **Quadrat = 40**

Table 4.3: Ecosystem categorization in swamp forest

Category	Characteristics	Subcategory	Characteristics	Primary sites	Secondary sites	Sampling unit	Plot design
Swamp Forest	1. high water table 2. fresh water intrusion	**Wetland /peat moss forest**	1. Mixed Species - palms, rattan, *Syzygium* sp., ferns 2. Often flooded 3. Presence of Shorea sp.,	Meludam NP	1 east side of river	5	Linear (40 x 5m) 200 m²
					2 west side of river	5	
					3 east side of river	5	Linear (40 x 5m) 200 m²
					4 east side of river	5	
				1	**4**	**20**	**Linear = 20**

Table 4.4: Ecosystem categorization in heath forest

Category	Characteristics	Subcategory	Characteristics	Primary sites	Secondary sites	Sampling unit	Plot design
Heath Forest	Sandstone formation with sedimentary rock	**Medium Closed heath forest**	1. Mixed species 2. Sandstone littoral	Bako NP	Paku trail	1	Circular (16m) 200 m²
						2	Linear (40 x 5m) 200 m²
						1	Quadrat (20x20m) 400 m²
					Lintang trail	5	Linear (40 x 5m) 200 m²
						4	Quadrat (20x20m) 400 m²
					Teluk Tajor	3	Linear (40 x 5m) 200 m²
					Teluk Silbur	2	Linear (40 x 5m) 200 m²
		Low closed heath forest	1. *Casuarina* /*Garcinia* dominant spp. 2. Sandstone	Bako NP	Pulau Lakie	2	Circular (16m) 200 m²
	Low and entirely flat land	**Flooded forest**	Dry ridge within mangrove	Kuching Wetland	Sungai Pergam	5	Linear (40 x 5m) 200 m²
					Sungai Selat	3	Linear (40 x 5m) 200 m²
				2	**7**	**28**	**Circular = 3** **Linear = 20** **Quadrat = 5**

Based on the above factors, three types of sampling unit designs were established in the secondary site locations. These sampling units were in the form of quadrat, linear (transects) and circular plots. The choice of sampling unit design was dictated by the steepness of the terrain and complexity of the vegetation. Each sampling unit was 200 m² for linear and circular plots, and 400 m² for quadrat (Figure 4.1).

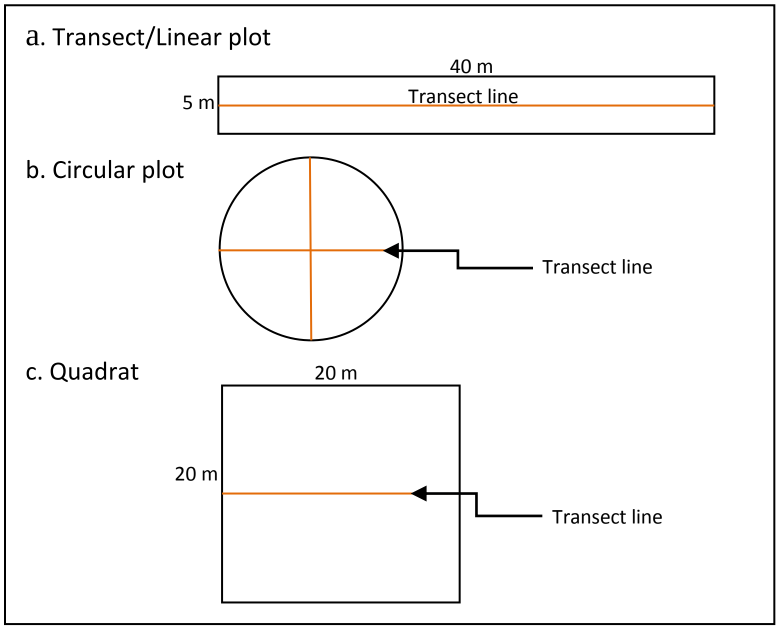


Figure 4.1: Sampling unit design

4.2.2 Habitat Assessment Variables and Specific Measures

Two approaches were engaged in designing field survey as follows.

a. **Variables and measures**: Assessment variables were based on a combination of factors such as known habitat use of Proboscis Monkey identified by the behavioural analysis undertaken in this research project and other literatures (Table 4.5).

b. **Recording process and techniques used**: Pretesting and refining formalized field data recording forms were done prior to the actual field work to suit the requirements of this study. During actual field work, informal incidental observations in the form of detailed additional notes were also undertaken. These techniques were based on rapid assessment methodology (Brown, Jennings, Wheeler, & Nabe-Nielsen, 2000; Ervin, 2003; Gibbons & Freudenberger, 2006) and standard ecological and forestry survey techniques (Alder & Synnott, 1992; Kanowski, Catterall, Freebody, Freeman, & Harrison, 2010).

Table 4.5: Factors affecting habitat use by Proboscis Monkey

Concept	Indicator	Justification
Habitat factor	Forest structure Food plants Connectivity Rivers Predation Forest types Disturbance	The survival of Proboscis Monkey in the wild depends on their habitat types. Habitat types are characterized by various biotic indicators that influence the monkeys' foraging behaviour.
Forest structure	D.B.H. distribution Canopy height Open and far reaching branches	D.B.H. ≥ 10 cm is common tree size on which Proboscis Monkey forage. Average canopy height of forest where Proboscis Monkey live is 10 – 20 m which depends on habitat types. Proboscis Monkey normally sleep on open and far reaching branches.
Food plants	Type of food plants	There are various species of food plants which have been indentified indicating Proboscis Monkey's diet varies according to habitat types. Proboscis Monkey's sleeping sites are close to food sources.
Connectivity	Gap size (mean gap size) Crown cover Canopy health	Connectivity and ease of movement through canopy. Healthy food plants with full crown cover provide a major source of food, especially young leaves. Dense canopy provides increased possibilities for escaping from predation besides abundance of food supply especially good foliage (no damage and dead branches)
Water body	Proboscis Monkey's sleeping sites near the rivers or water body, and near food sources	Ecologically Proboscis Monkey forages in a harem especially near rivers. They also sleep near rivers which provide some food plants and also increased chances of escape from predation.
Predation risk	Distance to water Mean tree height (Python, crocodile, leopard)	Proximity to water and risk of crocodiles. Vulnerability to ground predators. Minimum average of 10 m height from the ground when foraging on tree. (These wildlife have been reported as common predators of Proboscis Monkey)
Forest types	Mangrove, peat/swamp forest, riparian are normally habitats of Proboscis Monkey	These habitats supply food sources from young leaves, fruits, and seeds of food plants that are suitable for digestion.
Disturbance	Fragmented forest, man-made forests (plantation either native or exotic), agriculture, hunting, human related disturbance	Proboscis Monkey are not found living in open space and man-made forests due to insufficient food sources. Presence of exotic species is a threat to habitat quality

Based on the habitat indicators in Table 4.5 the following indicators were used for the assessment of habitat quality for the monkeys in this study (Table 4.6 and Table 4.7). The habitat quality assessment was based on the forest types in the study sites. The study sites were situated near the water bodies and were known to have predators.

Table 4.6: Habitat assessment indicators for heath and swamp forests

Habitat use indicators	Features and assessment rankings			
Forest structure	Dominated by some smaller trees. A few larger D.B.H. class. D.B.H. class varies. A number of emergent trees more than 20 m high.	Dominated by some smaller trees. A number of or a few larger D.B.H. class. D.B.H. class varies. No emergent trees more than 20 m high.	Dominated by majority of smaller trees with D.B.H. class 10-14 cm. No tree with D.B.H. class more than 20-24 cm. No emergent tree.	A number of smaller trees. No trees with D.B.H. class more than 10-14 cm.
Ranking	4 = good	3 = fairly good	2 = slightly poor	1 = poor
Food plant	Food plants vary. A few different species of food plants. Three or more species with density ≥ 100 trees per ha.	Less variety. A number of different species of food plants. One or two species with density ≥ 100 trees per ha.	Less variety of plants. Very little number of food plants. Only one species with density ≥ 100 trees per ha.	A single species. A number of food plants. Trees with density < 100 trees per ha.
Ranking	4 = good	3 = fairly good	2 = slightly poor	1 = poor
Connectivity	Minimal gap size (≤2 m wide). Dense canopy. No crowns damage.	Minimal gap size (≤2 m wide). Sparsely distribution of canopy. A number of crowns damage.	A number of large canopy gaps (≥2 m wide).	Some large canopy gaps (≥2 m wide).
Ranking	4 = good	3 = fairly good	2 = slightly poor	1 = poor
Disturbance	No removal of tree. No hunting and/or no burning of food plant species. Presence or absence of tourist.	Selective removal of trees rarely happens. No hunting and no burning of food plant species.	Selective removal of trees but regularly happens. No removal of trees but species lost due to environmental factors. No hunting and/or no burning of food plant species.	Selective removal of trees but regularly happens. Hunting and/or burning of food plant species
Ranking	4 =good	3 = fairly good	2 = slightly poor	1 =poor

Table 4.7: Habitat assessment indicators for coastal and riverine mangrove

Habitat use indicators	Features and assessment rankings			
Forest structure	Dominated by majority of or some smaller trees with D.B.H. class 10-14 cm. D.B.H. class varies with a few or a number of larger D.B.H. class. A number of or no emergent tree more than 20 m high.	Dominated by majority of or some smaller trees with D.B.H. class 10-14 cm. No tree with D.B.H. class more than 20-24 cm and a number of emergent trees more than 20 m high.	Dominated by some or majority of smaller trees with D.B.H. class 10-14 cm. No trees with D.B.H. more than 15-19 cm or 25-29 cm and no emergent tree more than 20 m high.	A number of smaller trees. No trees with D.B.H. class more than 10-14 cm.
Ranking	4 = good	3 = fairly good	2 = slightly poor	1 = poor
Food plants	Food plants vary. A few different species of food plants. Three or more species with density 100-300 trees per ha or more than 300 trees per ha or a number of food plant species more than 300 trees per ha.	A number of food plants and one or two species with density 100-300 trees per ha or more than 300 trees per ha, or a number of different species of food plants and two species with density 100-300 trees per ha or more than 300 trees per ha	Less variety. Only one species with density 100-300 trees per ha or more than 300 trees per ha.	A single species. A number of food plants. No trees with density more than 100 trees per ha.
Ranking	4 = good	3 = fairly good	2 = slightly poor	1 = poor
Connectivity	Minimal gap size (≤2 m wide). Dense canopy and no crowns damage.	Minimal gap size and sparsely distribution of canopy. A number of crowns damage.	A number of large canopy gaps.	Some large canopy gaps (≥2 m wide).
Ranking	4 = good	3 = fairly good	2 = slightly poor	1 = poor
Disturbance	No removal of tree. No hunting and/or burning of food plant species. Presence or absence of tourist.	No removal of tree but species lost due to environmental factor. Selective removal of trees rarely happens. No hunting and no burning of food plant species.	Fragmented. Selective removal of trees rarely happens.	Isolated and surrounded by land clearing.
Ranking	4 = good	3 = fairly good	2 = slightly poor	1 = poor

4.3 RESULTS

Based on the habitat quality indicators, the forest structure and composition including the threatening processes inside and outside the study sites were assessed and the summary of results is shown in Table 4.8 and Table 4.9 below.

Table 4.8: Summary of habitat assessment results for heath and swamp forests

Habitat use indicators	Medium closed heath forests	Low closed heath forests	Flooded forests	Peat moss forests
Forest structure	4 = good	2 = slightly poor	3 = fairly good	3 = fairly good
Food plant	4 = good	3 = fairly good	3 = fairly good	3 = fairly good
Connectivity	3 = fairly good	3 = fairly good	2 = slightly poor	1 = poor
Disturbance	4 =good	3 = fairly good	3 = fairly good	1 =poor

Table 4.9: Summary of habitat assessment results for coastal and riverine mangroves

Habitat use indicators	Coastal Mangrove Forests			Riverine Mangrove Forests		
	BNP		Selabat	KWNP	Selabat	Bako High School
	Teluk Assam	Teluk Delima				
Forest structure	3 = fairly good	4 = good	4 = good	4 = good	2 = slightly poor	2 = slightly poor
Food plants	1 = poor	3 = fairly good	2 = slightly poor	4 = good	3=fairly good	3 = fairly good
Connectivity	2 = slightly poor	4 = good	2 = slightly poor	3 = fairly good	2 = slightly poor	3=fairly good
Disturbance	3=fairly good	4=good	3=fairly good	3=fairly good	3-fairly good	1=poor

4.3.1 Heath Forest

Layout of sampling units (SUs) at Paku Trail, Litang Trail, Tajor Trail, and Sibur Trail are depicted in Figure 4.2a. SUs at Pak Amit Trail in Pulau Lakei are shown in Figure 4.2b. These locations were categorized as medium closed heath forests (heath forests in Bako National Park mainland), and low closed heath forests (heath forests in Pulau Lakei – Bako National Park). Proboscis Monkey was mostly sighted in Paku and Lintang Trails during this study. Proboscis Monkey was also frequently sighted in Sibur Trail in the past but rarely found in Tajor Trail and Pulau Lakei. In the flooded forests (heath forests in Kuching Wetland National Park), SUs were established near Sg. Pergam Besar and Sg. Selat, a tributary of Sg. Pergam Besar (Figure 4.3). Proboscis Monkey was rarely sighted in the flooded forests but were most frequently observed within the mangrove forests of Kuching Wetland National Park.

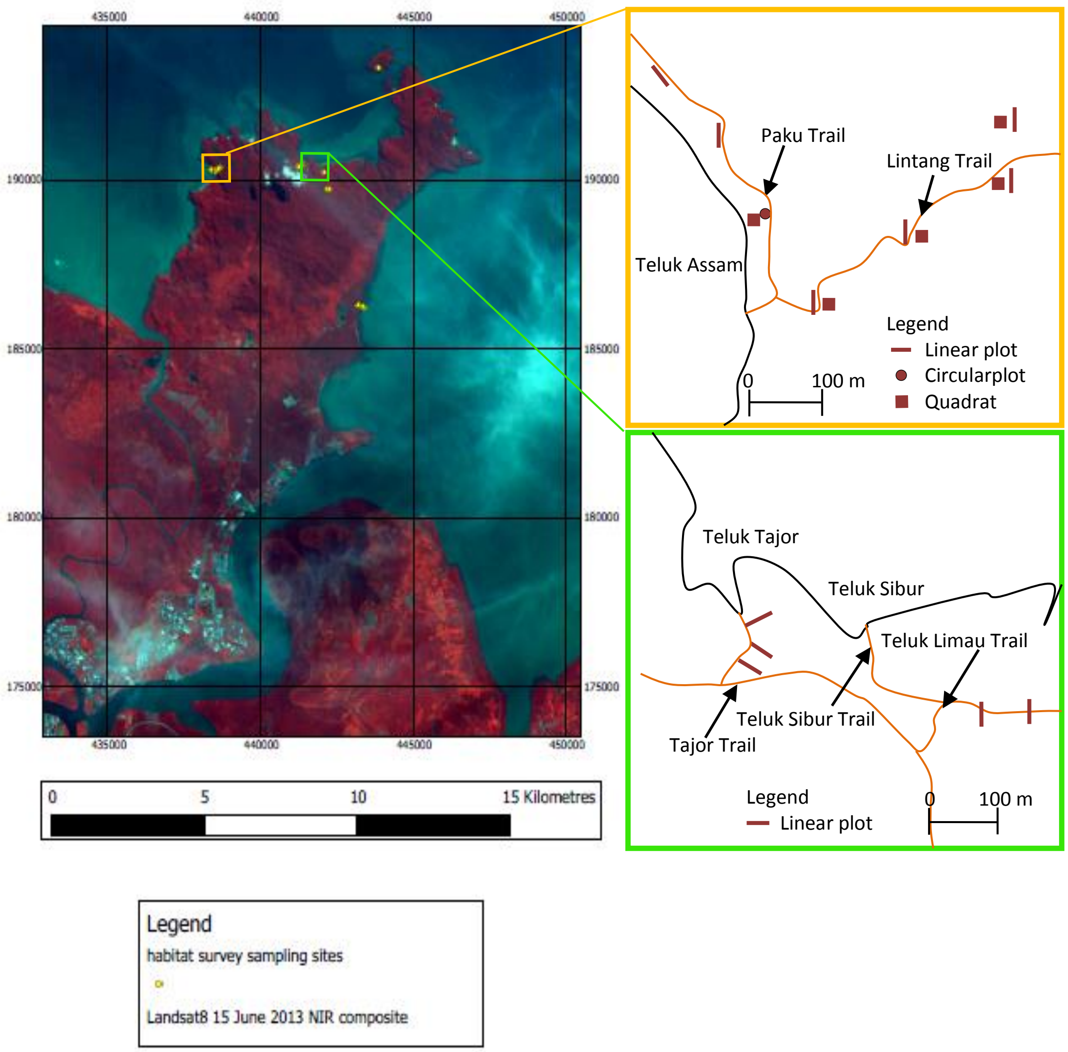


Figure 4.2a: Layout of sampling uints at Paku, Lintang, Tajor and Sibur Trails – Bako National Park

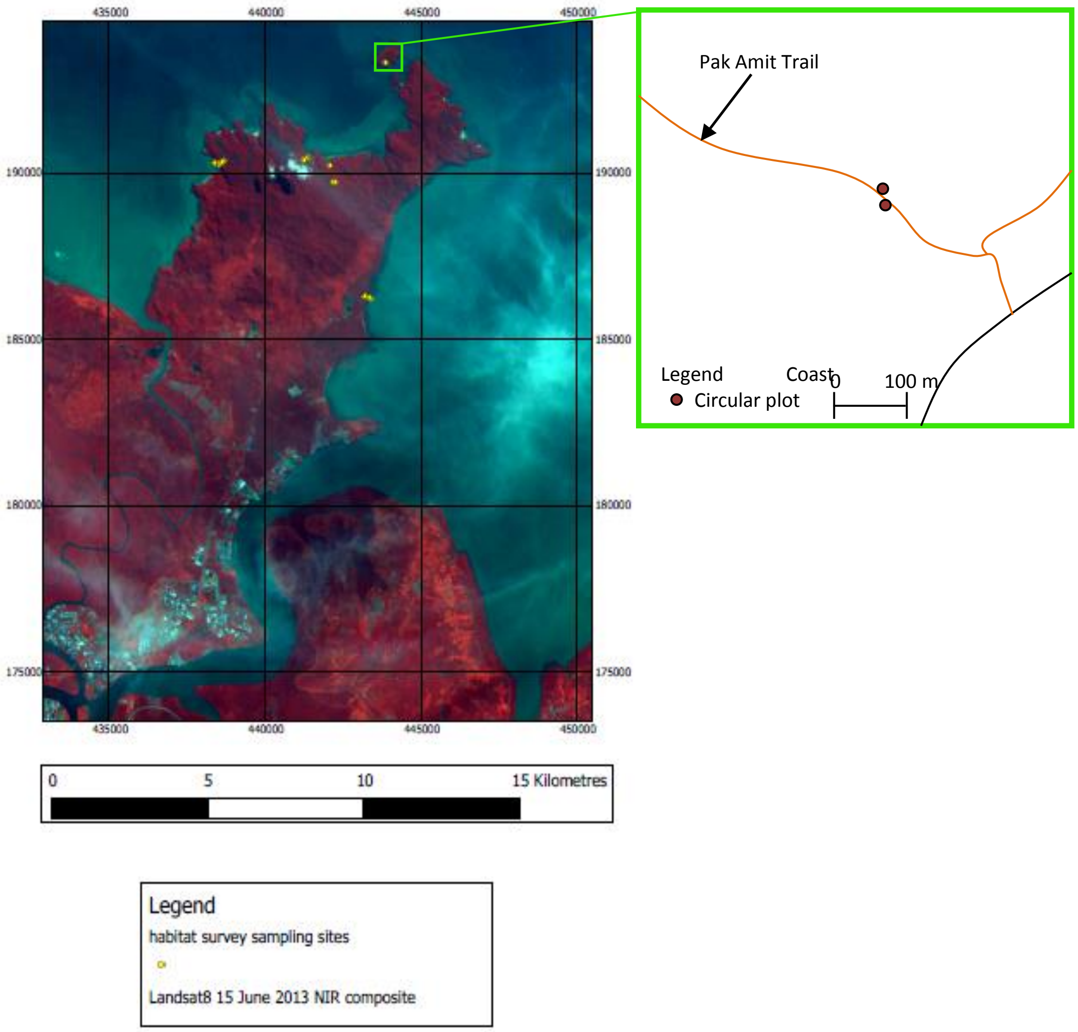


Figure 4.2b: Layout of sampling units at Pulau Lakei – Bako National Park

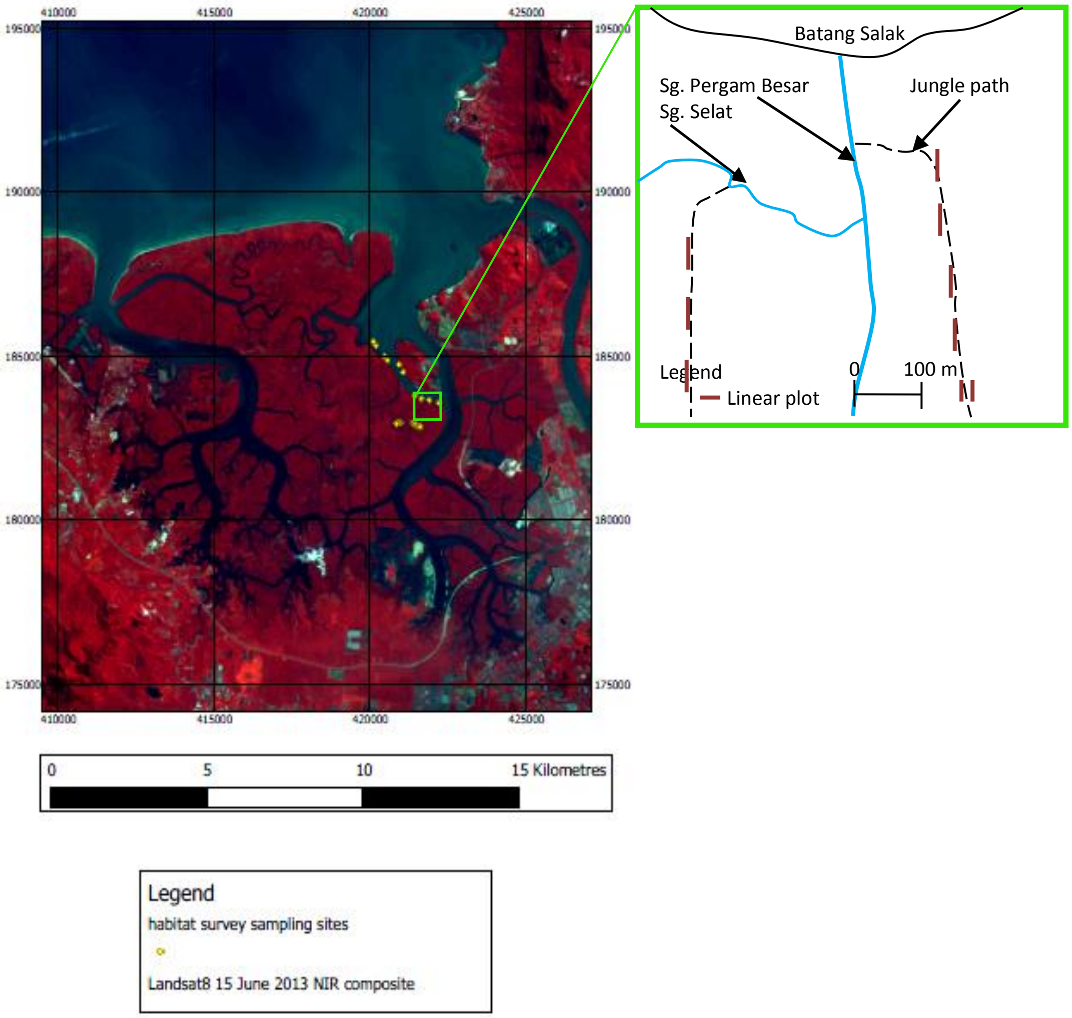


Figure 4.3: Layout of sampling units at Kuching Wetland National Park

Some differences in landscape patterns are evident as shown in Figure 4.4 and Figure 4.5 between 2004 and 2013. The landscape changes mostly occurred outside the protected areas, especially at the settlement areas.

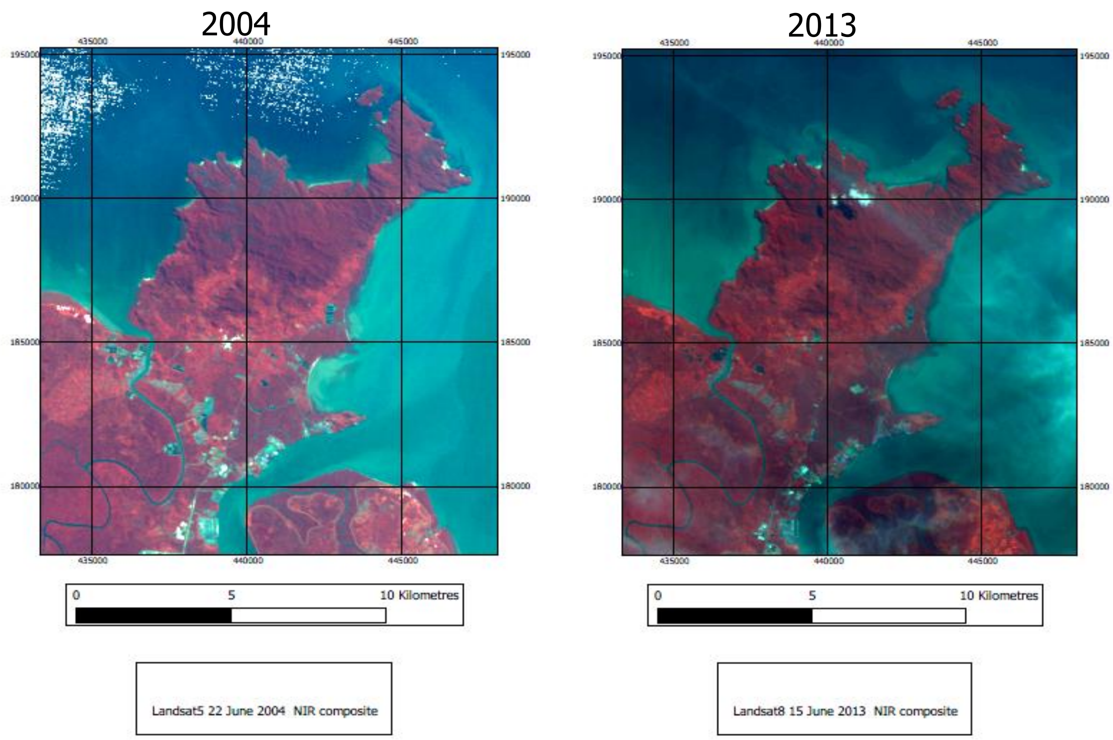


Figure 4.4: Landscape patterns in the study sites – Bako National Park

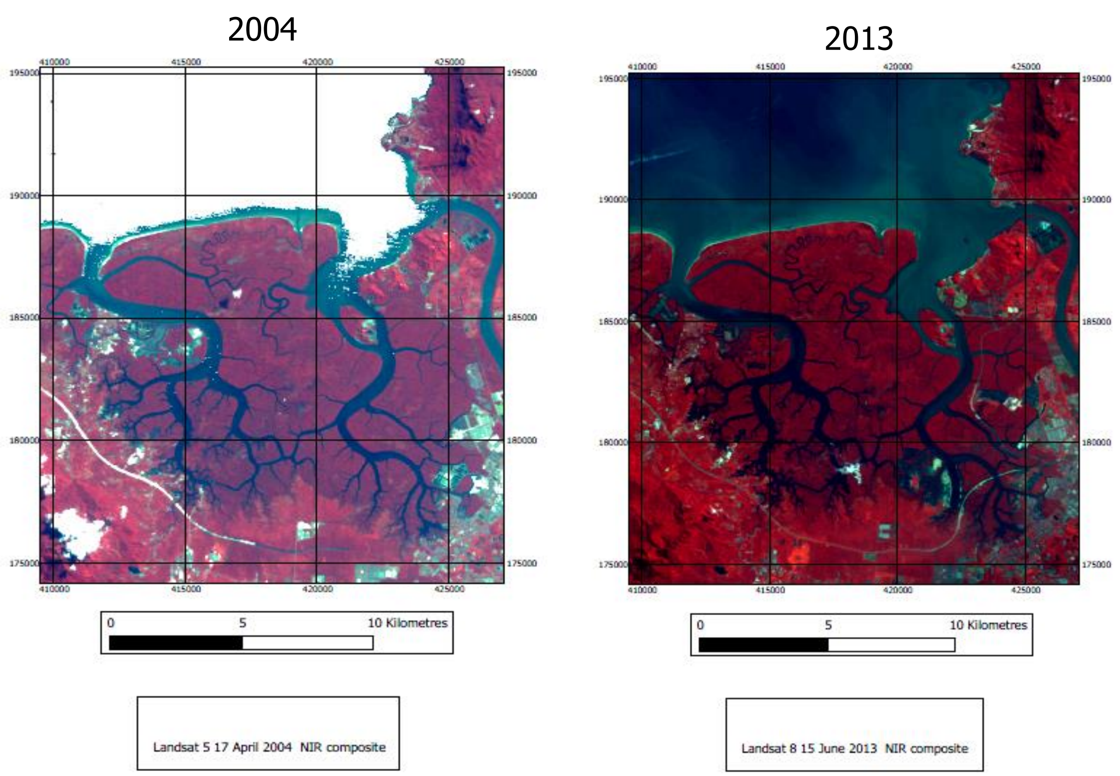


Figure 4.5: Landscape patterns in the study sites – Kuching Wetland National Park

a. ***Medium closed heath forest***

Proboscis Monkey's habitat in the medium closed heath forest was characterized by various D.B.H. classes of trees from 10 cm to 70 cm (Appendix 3). SUs with higher numbers of larger trees had the higher basal area. This was evident in SU 2 with a basal area of 85.91 m² per ha which was higher than other SUs. In contrast, the higher numbers of smaller trees had the lower basal area. The lower basal area was 9.72 m² per ha derived from SU 14. Mean (±SD) values for each sample variable for this ecosystem are shown in Table 4.10. These sample variables depict the quality and structure of the medium closed heathforest in 18 SUs.

The location of the SUs seemed to influence the composition and structure of trees enumerated. The smaller trees were more evident in SUs located at higher elevations on forest ridges, in particular SUs on Sibur Trail as opposed to other SUs. Some trees were less than 10 m high due to a number of SUs located at more than 100 m above the sea level. Some of the tree canopies formed good connectivity inside the SUs although the transect line was not fully covered by tree crowns. There were 12 trees which provide sleeping sites were enumerated in SUs at Paku and Lintang Trails, whereas 4 branching trees were from SUs at Paku Trail.

Table 4.10: Summary statistics of variables in the medium closed heath forest

	Mean ± SD	Range
D.B.H. cm (n = 381)	18.47 ± 9.44	10.00 - 70.50
Height m (n = 381)	10.52 ± 4.92	2.50 - 25.00
Basal area (BA) m^2/ha (n = 381)	1.44 ± 2.15	0.20 - 19.52
Crown cover m (n = 48)	4.31 ± 3.19	1.00 - 16.00
Canopy gap m (n = 7)	6.26 ± 6.23	1.40 - 17.00
Number of branching trees (n = 4)	3.50 ± 1.73	2.00 – 6.00
Distance from water body* m (n = 18)	176.67 ± 116.97	10.00 – 350.00
Number of tree which provides sleeping site (n = 12)	2.17 ± 0.94	1.00 – 4.00
Elevation m (n = 8)	78.83 ± 32.18	25.00 - 127.00
Slope % (n = 18)	10.50 ± 3.15	5.00 - 17.00

* river or coast

b. *Low closed heath forest*

The two SUs in this forest were mostly occupied by trees with D.B.H. class 10-14 cm (Appendix 3). The representation of D.B.H. class 10-14 cm in SU 1 was higher than in SU 2 such that the basal area was higher in SU 1 (19.83 m² per ha) as opposed to SU 2 (11.43 m² per ha). The higher representation of smaller trees with or under 5 m high could indicate that this forest may have nutrient deficiency. The shallow soil conditions with silica rich substrate is also a limiting factor on tree growth in this secondary study site. Mean (±SD) values for sample variables for this category of ecosystems are shown in Table 4.11.

Table 4.11: Summary statistics of variables in the low closed heath forest

	Mean ± SD	Range
D.B.H. cm (n = 50)	12.20 ± 3.25	10.00 - 29.50
Height m (n = 50)	4.95 ± 1.23	3.00 - 8.00
Basal area (BA) m² (n = 50)	0.63 ± 4.67	0.39 - 3.42
Crown cover m (n = 11)	4.44 ± 1.87	1.80 - 7.50
Canopy gap m (n = 0)		
Number of branching trees (n = 4)	2.25 ± 0.50	2.00 – 3.00
Distance from water body*m (n = 2)	100.00±0.00	100.00 – 100.00
Number of tree which provides sleeping site (n = 1)	1	1.00 – 1.00
Elevation m (n = 2)	39.50± 2.12	38.00 - 41.00
Slope % (n = 2)	5.00 ± 0.00	5.00 - 5.00

* river or coast

c. *Flooded forest*

Some parts of this forest were flooded during high tide especially the areas at or under 5 m above sea level. The D.B.H. class 10-14 cm represented the highest number of trees in this habitat (Appendix 3). The higher basal area was derived from SU 5 (33.38 m² per ha), whereas the lower basal area (12.69 m² per ha) from SU 1 of Site 1. The higher basal area in SU 5 is related to a higher number of larger trees above the D.B.H. class 10-14 cm. It was evident that many trees with various sizes were removed from Site 2 which explains the lesser number of trees with smaller D.B.H. class available compared to Site 1. Mean (±SD) values for sample variables for this ecosystem are shown in Table 4.12. Of 146 trees sampled, four trees had the characteristics of sleeping sites for Proboscis Monkey.

Table 4.12: Summary statistics of variables in the flooded forest

	Mean ± SD	Range
D.B.H. cm (n = 146)	15.90 ± 6.70	10.00 - 43.00
Height m (n = 146)	6.90 ± 2.90	3.00 - 16.00
Basal area (BA)m² (n = 146)	1.17 ± 1.14	0.39 - 7.26
Crown cover m (n = 14)	4.34 ± 3.05	1.00 - 12.00
Canopy gap m (n = 2)	34.80 ± 3.25	32.50 - 37.10
Number of branching trees (n = 10)	2.60 ± 0.84	2.00 -4.00
Distance from water body*m (n = 8)	81.25±57.92	20.00 – 200.00
Number of tree which provides sleeping site (n = 4)	1.50 ±1.00	1.00 – 3.00
Elevation m (n = 8)	10.12± 6.08	5.00 - 20.00
Slope % (n =1)	10.00	10.00 - 10.00

* river or coast

Plant Species Recorded

Species names as per Appendix 4 were enumerated in SUs from the medium closed heath forest, the low closed heath forest and the flooded forest. These three categories of ecosystems were characterized by various plant species. Of 106 species names, 24 names were food plants obtained from this research. The density of tree species with D.B.H. ≥ 10 cm in each SU is shown in Figure 4.6, Figure 4.7 and Figure 4.8. There was a higher density of *Garcinia cuneifolia* Pierre and *Shorea* sp. (113 trees per ha respectively) in the medium closed heath forest at Paku Trail (Figure 4.6a), *Whiteodendron moultonianum* (78 trees per ha and 200 tree per ha) at both Lintang Trail (Figure 4.6b) and Tajor Trail (Figure 4.6c), and *Dacrydium* sp. (200 tree per ha) at Sibur Trail (Figure 4.6d). In the low closed heath forest, *Gymnostoma nobile* (325 tree per ha) was abundant (Figure 4.7). *Garcinia cuneifolia* was abundant (100 trees per ha) in the flooded forest at Sg. Pergam Besar (Figure 4.8a) as was *Shorea* sp. and *Vatica* sp. (133 trees per ha respectively) at Sg. Selat (Figure 4.8b). Overall, the result suggests that the medium closed heath forest, especially SUs at Paku Trail, contained a higher density of food plants preferred by Proboscis Monkey.

a. ***Medium closed heath forest***

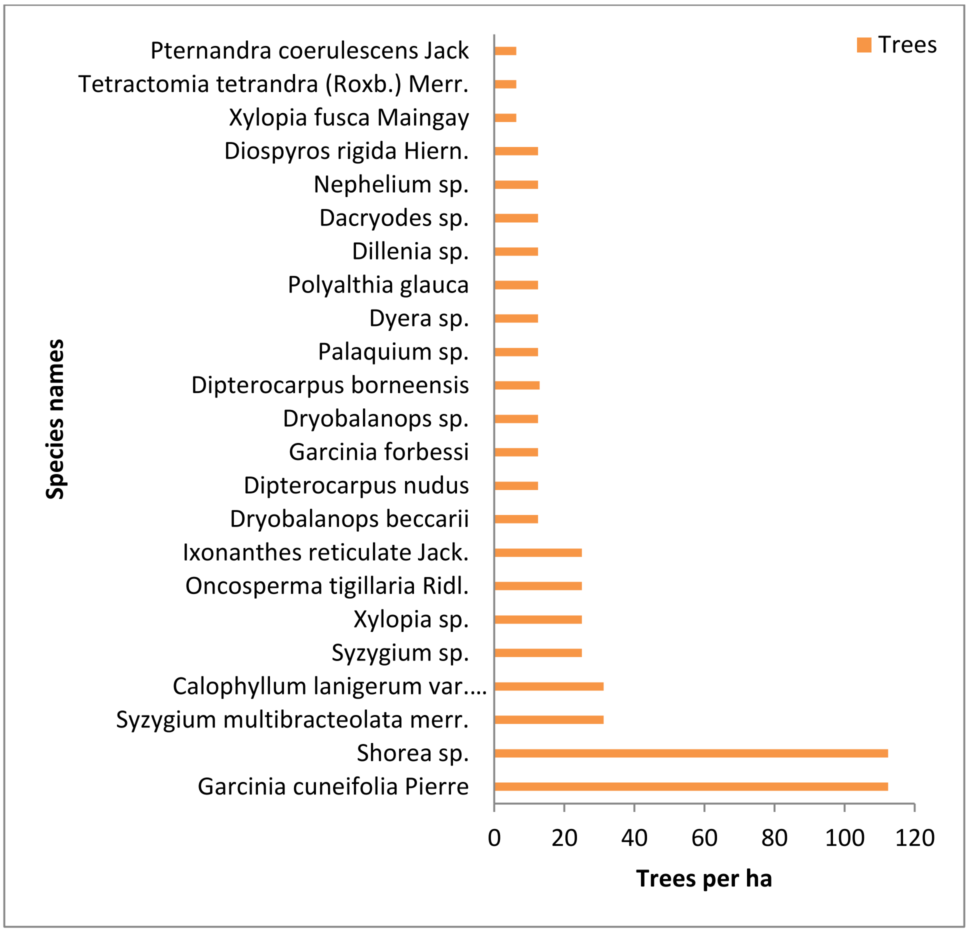


Figure 4.6a: Species abundance on Paku Trail in the medium closed heath forest

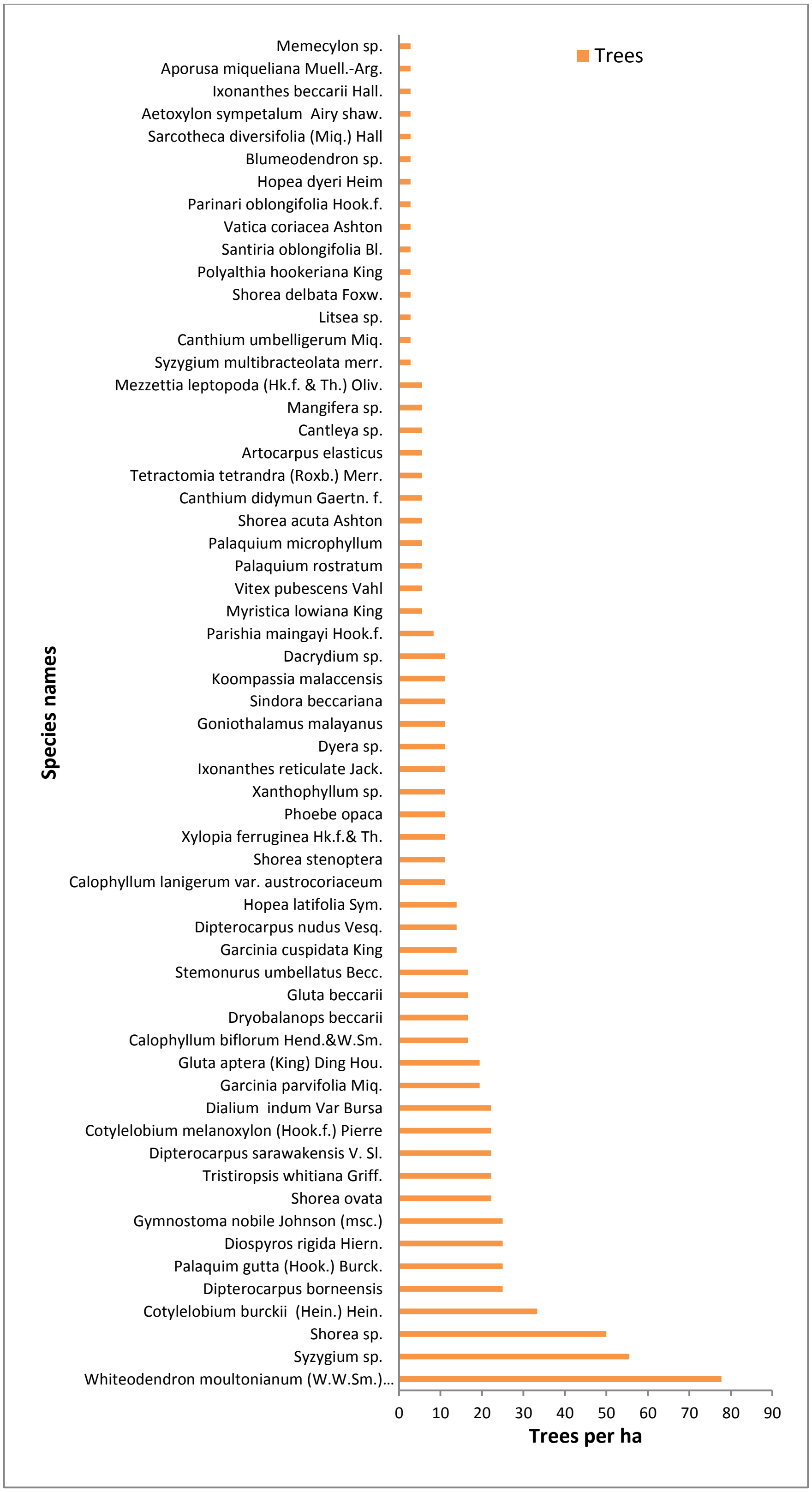


Figure 4.6b: Species abundance on Lintang Trail in the medium closed heath forest

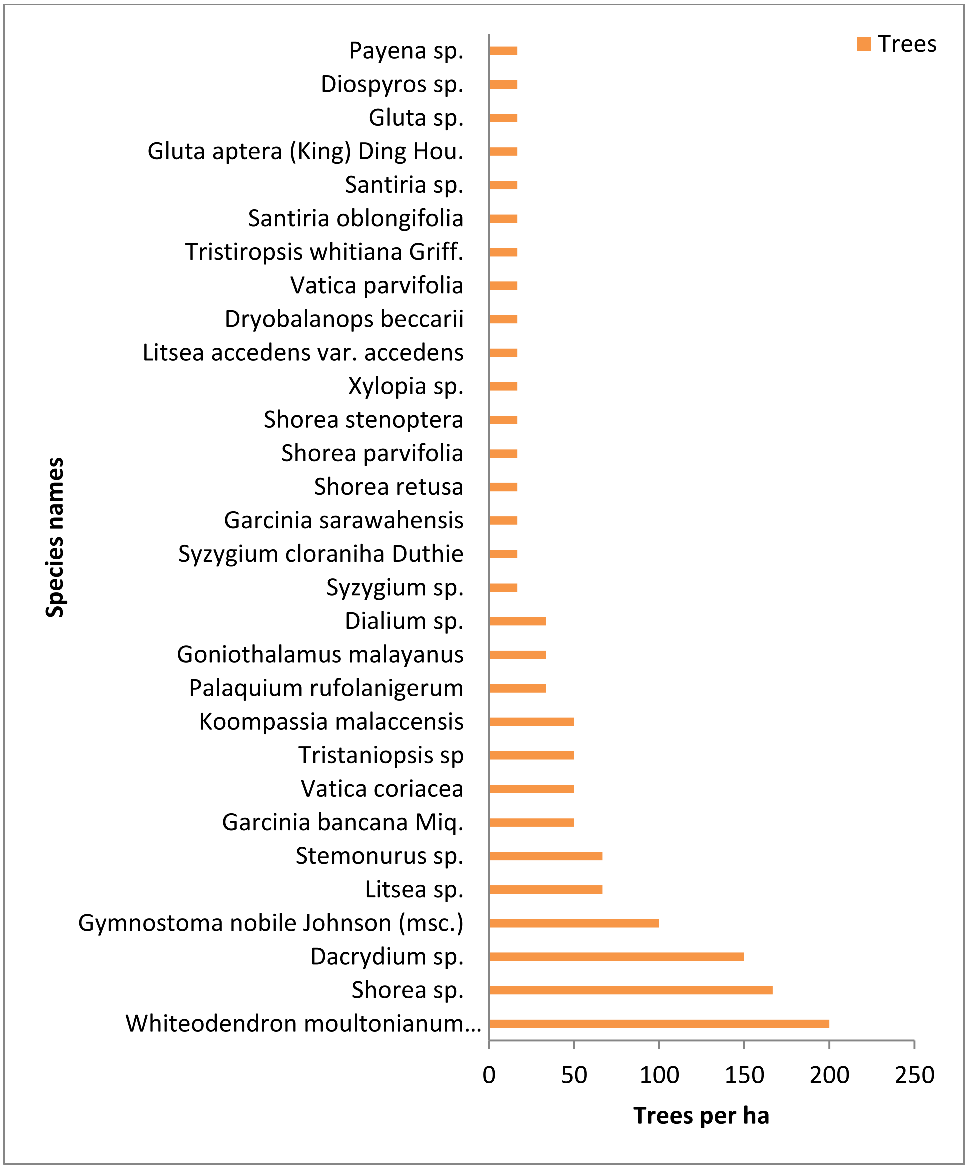


Figure 4.6c: Species abundance on Teluk Tajor Trail in the medium closed heath forest

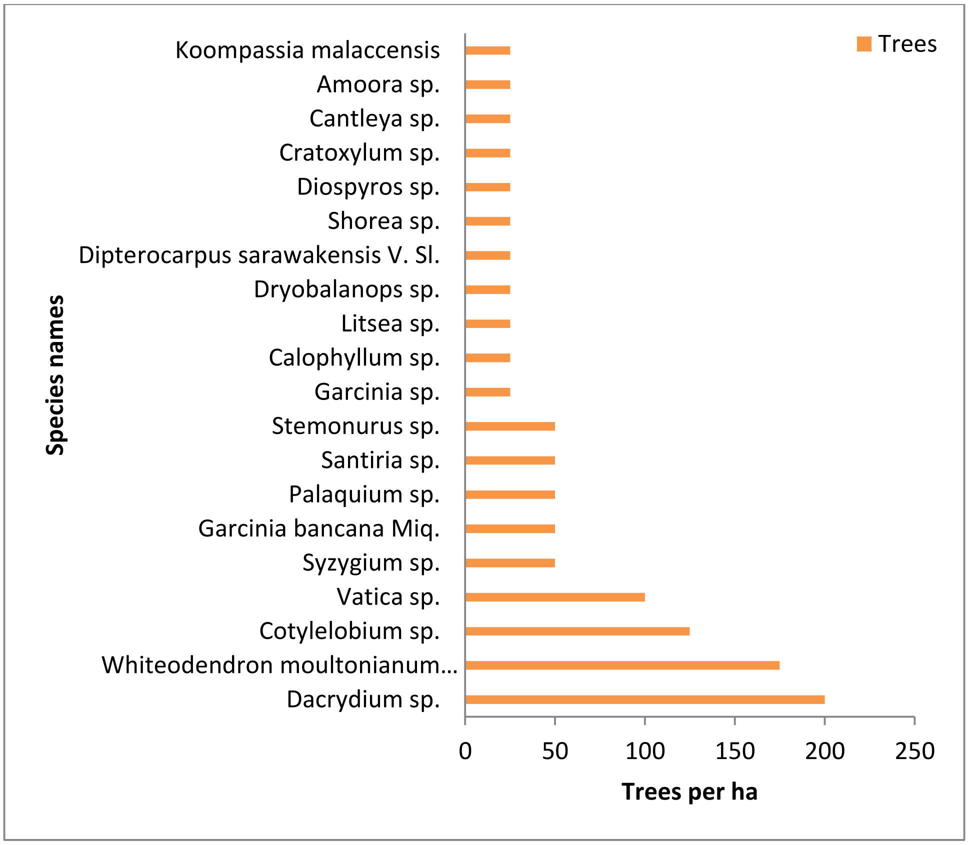


Figure 4.6d: Species abundance on Teluk Sibur Trail in the medium closed heath forest

b. ***Low closed heath forest***

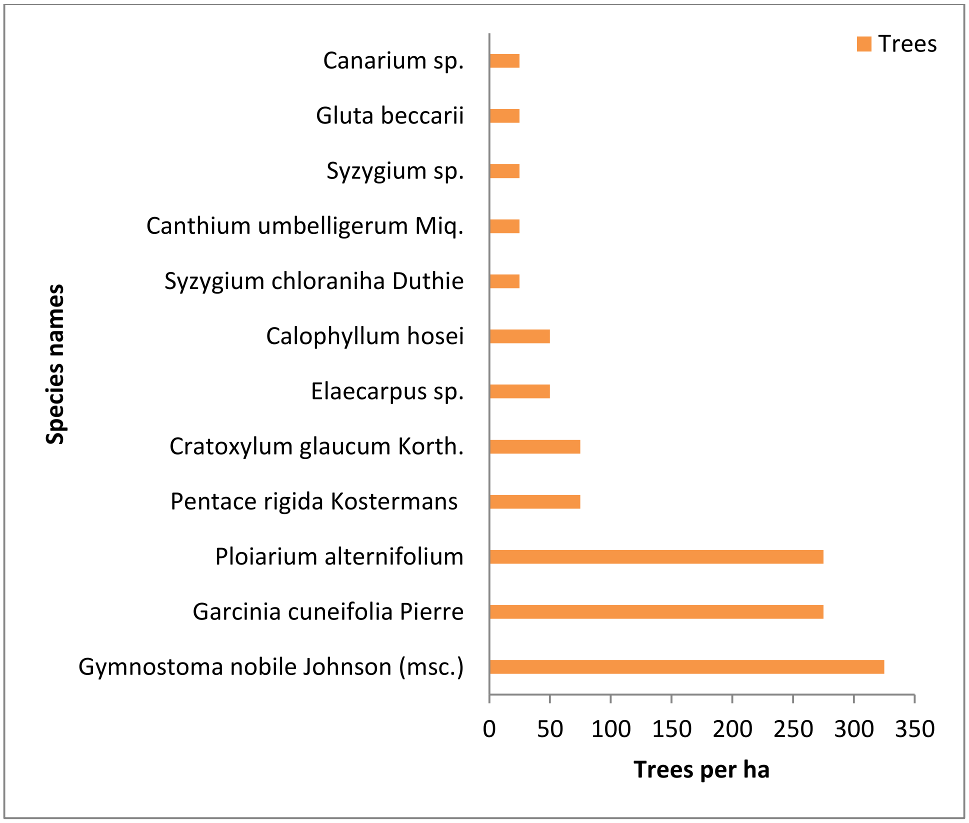


Figure 4.7: Species abundance from SU at Pulau Lakei

c. *Flooded forest*

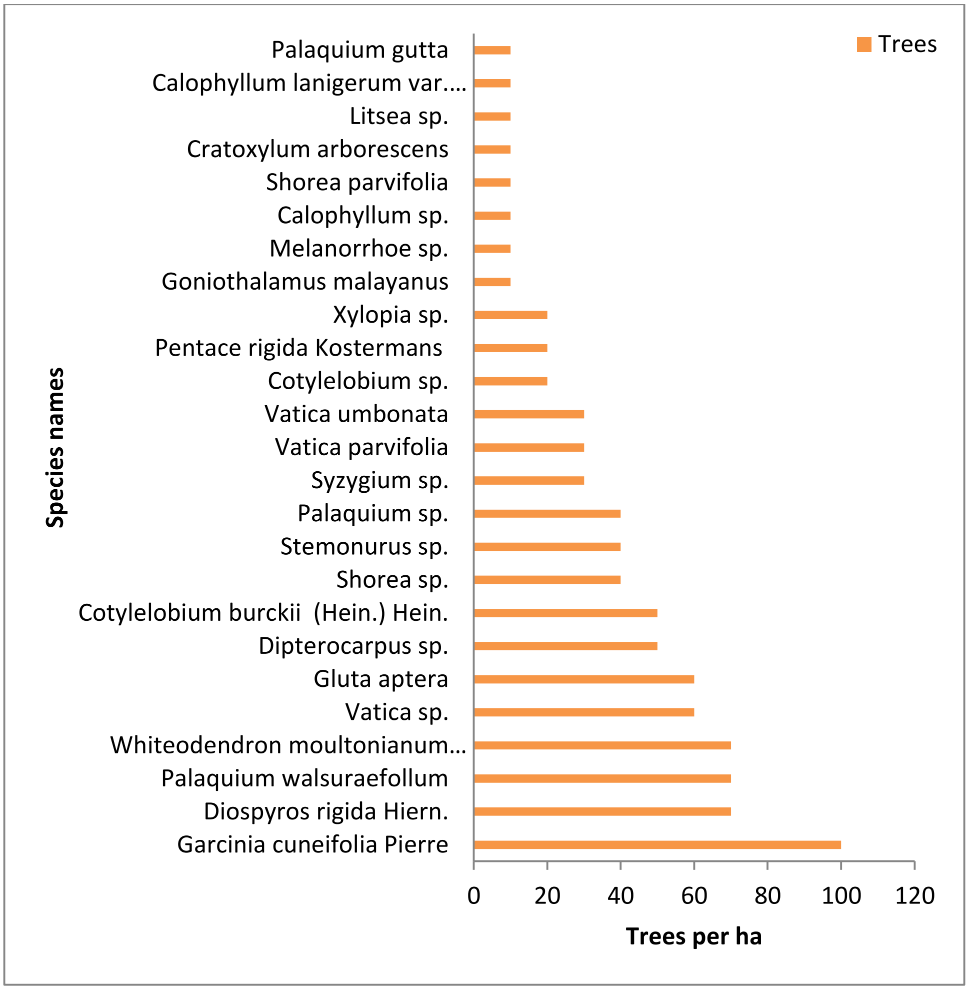


Figure 4.8a: Species abundance at Site 1 Sg. Pergam Besar

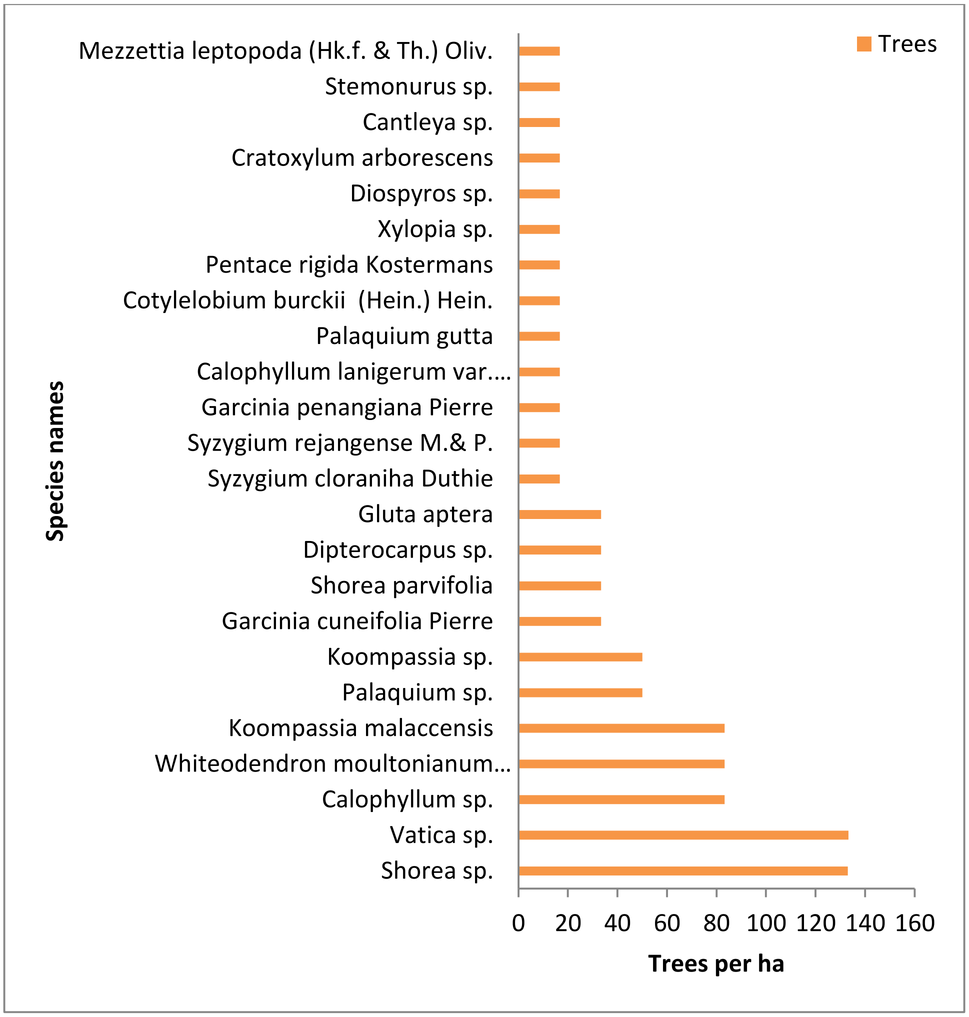


Figure 4.8b: Species abundance at Site 2 Sg. Selat

Tree Profile

a. *Medium closed heath forest*

Connectivity and canopy health of the medium closed heath forests were mostly of good quality. Good connectivity as shown in SUs at Paku Trail (Appendix 5) may suggest ease of movement for the monkeys through canopy. Canopy health in SUs at Paku Trail was also good except two trees on the transect line 1 in SU 1. One of the tree crowns was good and another one was in moderately good health with two canopy gaps of 1.6 m and 1.8 m long respectively. Average length of crown cover for these two trees was 3.1 m. A fairly good connectivity was present in this natural setting although almost half of the transect line 2 of SU 1 had no trees. The remaining distance along the transect line 2 was covered by the canopy of trees off the transect line. In SU 7 at Paku Trail, the average length of crown cover of two trees on the transect line was 11 m and crown health was good. This transect had no canopy gaps and good connectivity. Conversely, a fairly good connectivity was found in SU 8 and SU 14 at Paku Trail. Although the transect line in SU 8 had good crown health of trees, it had a 4 m long canopy gap and only 3.4 m long crown cover. SU 14 had two trees with good crown health on the transect line. These trees had an average of 4.3 m long crown cover and 1 (one) m of canopy gap on the transect line.

SUs at Lintang Trail had no canopy gap except SU 3 and SU4. Connectivity on the transect line in SU 3 was poor compared to other SUs at this trail. There were only two trees on the transect line with 13 m long canopy gaps. Crown health of one of these trees was very poor. The remaining distance of transect line was covered by branches of trees off the transect line. However, connectivity outside the transect line was good. In SU 4, there were only three trees with good crown health and an average of 4.2 m long crown cover. However this transects line was covered by trees intermittently along its length which resulted in good connectivity. Transect line 2 was sparsely covered by branches of trees off the transect line although there were no trees on the transect line itself. As a result, some canopy gaps were noticed. In contrast, SU 2 was composed of good connectivity and no canopy gap along the transect line. The transect line was covered by all six trees on the transect line with good crown health. The average crown cover was 10.5 m long.

There was no canopy gap along the transect line 1 in SU 5 at Lintang Trail. Although only three trees occurred on the transect line, branches of trees off the transect line also covered the transect line and provided complete canopy coverage. Average length of crown cover on transect line 1 was 2.4 m and the crown health of one of these trees was moderately good. Transect line 2 was covered by trees both on and off the transect line, such that no canopy gap existed. These two trees had good crown health and average length of crown cover was 1.8 m. On the transect line in SU 6 only two trees occurred, with fairly good crown health and an average crown cover length of 3.8 m. The transect line was covered by tree crowns from both on and off the transect line which resulted in good connectivity. The transect line in SU 15 had two trees also, with an average of 4 m long of crown cover. Both of these trees had good crown health. Canopy connectivity was good with no canopy gap. There was only one tree on the transect line in SU 16, which was in good health with a crown cover length of 6 m. This transect line was also covered by other branches of trees off the transect line, resulting in no canopy gaps. In SU 17, three trees on transect line had good crown health, and the crown cover average was 4.5 m long. On the transect line, no canopy gap was observed. On the other hand, there were five trees on transect line in SU 18, which had good crown health with crown cover average of 3.9 m.

Tajor Trail had fairly good canopy health with only had 5 m long of canopy gap on the transect line in SU 10. On the transect line in SU 10 only five trees occurred, with an average crown cover length of 4 m. Two of these trees had good crown health and others had fairly good crown health. SU 9 had good connectivity and no canopy gap along the transect line. There were eight trees on the transect line, and four of them had good crown health and others fairly good. SU 11 had seven trees on the transect line. Of these, five trees had good crown health, one fairly good and another one poor. These trees had crown cover average of 3.5 m. There was no canopy gap which resulted in good connectivity. There were only two SUs at Sibur Trail. Both SUs had canopy gaps on the transect lines. SU 12 had canopy gap of 17 m long on the transect line. Its connectivity was not good, which only three trees on the transect line with an average of 2 m long crown cover. The crown health was both fairly good and poor. SU 13 had two trees on the transect line with fair and good crown health respectively. Average length of crown cover on the transect line was 6.6 m and canopy gap was 1.4 m long. However, the areas off the transect line were covered by the tree canopy. Overall, connectivity and canopy health were good in this habitat, which provided good arboreal route and sleeping sites for Proboscis Monkey.

b. *Low closed heath forest*

Profile of stands in the low closed heath forest is shown in Appendix 5. There were only two SUs in this habitat with good connectivity. However, the connectivity outside these SUs was fairly good. The transect line was covered by tree canopy and no canopy gap was observed as shown in SU 1. There were 50 trees in both SUs with good connectivity along the transect line. Of 29 trees in SU 1, only two trees on the transect line 1 and three trees on the transect line 2. Crown health of both trees on the transect line 1 was good and crown cover average was 2.9 m long. Crown health of both trees on the transect line 2 were good and fairly good. Their crown cover average was 2.7 m long. There were 21 trees in SU 2, and of these, three trees on the transect 1 and three on the transect line 2. Average length of crown cover was 1 m on the transect line 1 and 0.7 m on the transect line 2. Crown health of trees on the transect line 1 was fairly good. Crown health ofboth trees on the transect line 2 was good and fairly good. However, canopy health and connectivity outside these SUs were fairly good, with sparsely distribution of canopy gaps. This indicates low quality habitat, which explains the sighting of Proboscis Monkey was very hard.

c. *Flooded forest*

The profile of stands from eight SUs in the flooded forest (Appendix 5) showed unevenly forest structure and vegetation composition due to the past removal of trees. There was no tree on the transect line in SU 1 at Sg. Pergam, although this

SU had 17 trees with fairly good canopy health. It had sparsely distribution of canopy gap, which resulted in poor connectivity. SU 2 was composed of 23 trees with canopy gap present along the transect line. Average length of crown cover of both trees on the transect line was 1.9 m and crown health were fairly good and poor. SU 3 was only composed of 15 trees. Of this, only four trees on the transect line. Average length of crown cover of these trees was 3.6 m and crown health was good and fairly good. Canopy gap existed and distributed sparsely along the transect line. In SU 4, there were two trees on the transect line, with moderately good and good crown health. Crown cover length of these trees was 2.5 m. Canopy gap distributed sparsely along the transect line. SU 5 had 23 trees and of this only one tree on the transect line with good crown health. Transect line was fully covered by tree canopy, which resulted in no canopy gap.

The profile of trees in SU 6 at Sg. Selat is shown in Figure 4.14f. There were 15 trees in this SU and of this only one tree on the transect line with good crown health. The crown cover of this tree was 2.9 m long. There was a canopy gap on the transect line such that connectivity was slightly poor. In SU 7, there were two trees on the transect line with good crown health. Average length of crown cover of these trees was 3.7 m. The total number of trees in SU 7 were 19, with sparsely distribution of canopy cover on the transect line. SU 8 was composed of 24 trees and of this two trees were on the transect line. Both trees on the transect line had good crown health and average length of crown cover was 2.5 m. Connectivity was fairly good although there was canopy gaps on the transect line. Overall, connectivity and canopy health in this habitat were slightly poor.

Proboscis Monkey and Other Species Occurrence

Sighting of primates in Bako National Park and Kuching Wetland National Park was not always easy, with the exception of the Long-tailed Macaque. Table 4.13 summarises sightings of Proboscis Monkey and other species of wildlife in the study area.

Table 4.13: Species of wildlife sightings in the heath forests of the study sites

Wildlife	Site	Literature	This study	Local people
Proboscis Monkey	BNP KWNP	September 2005 December 2008 (FDS, 2010a)	June 2013	June 2013
Silvered Langur	BNP KWNP	December 2008	November 2011	November 2011
Long-tailed Macaque	BNP KWNP	December 2008	April 2012	
Flying Lemur	BNP KWNP	2007 (Beavitt & Tuen, 2010)	November 2011	
Civet Cat	BNP		September 2011	
Python	BNP		January 2012	

Proboscis Monkey was mostly sighted at Paku Trail in the morning, afternoon and late afternoon from May 2011 to May 2012 over the study period. Silvered Langur was rarely found in the park, but Long-tailed Macaque was easy to sight. Both Flying Lemur (*Cynocephalus* sp.) and Civet Cat (*Paradoxurus* sp.) were incidentally sighted once.

Discussion

Based on habitat characteristics and forest structure, habitat types among the study sites varied. They have their own respective strengths and weaknesses in relation to habitat quality, which may affect the long-term survival of the monkeys. The forest ecosystems in the medium closed heath forest and the low closed heath forest of Bako National Park are still intact and there was no occurrence of serious anthropogenic activity, particularly illegal cutting of timber, within the ecosystems. However, Paku and Lintang Trails experienced heavy visitor use and activity on trails (Budeng, 2004). This happens within most national parks of the world which recognize the dual function of protecting wildlife habitat and promoting tourism for the enjoyment of visitors (Sharpley & Pearce, 2007). There was no evidence of habitat loss in this type of ecosystem except ecosystems outside the park which showed reductions of forest species diversity.

Disturbance of ecosystems outside the park occurred in an unsustainable manner due to uncontrolled land-use practices such as land clearing by private land owners. Human settlements and private land clearing for subsistence cultivations occur in the southern area beyond the Bako National Park boundary. This land-use practice has created an open space and changed the forest structure. Proboscis Monkey is very sensitive to disturbance (Sha et al., 2008), and never found foraging on open ground (Bennett & Gombek, 1993) or agricultural land.

Fragmented habitat is not suitable for Proboscis Monkey (Sha et al., 2008) as it not only limits its arboreal movements (Arroyo-Rodríguez et al., 2008) but also affects the quality of its habitats (Arroyo-Rodríguez & Dias, 2010; Arroyo-Rodríguez et al., 2008; da Silva Junior et al., 2010; Pyritz et al., 2010).

Land clearing followed by open burning modifies the microclimate which leads to changes in plant composition and structure (Arroyo-Rodríguez & Dias, 2010; Arroyo-Rodríguez et al., 2008), pollutes the environment, creates fragmented and isolated landscapes and diminishes wildlife corridors. Therefore, the quality of habitats outside these medium and low closed heath forests was very poor. The unsustainable land-use practices may have long-term impacts on the habitat quality unless a serious commitment is initiated to incorporate land-use planning outside the park boundary into the park management. This commitment could potentially be achieved through the established joint committees, especially the Special Park Committees and the Special Wildlife Committees.

Forest composition in the medium closed heath forest of Bako National Park was better than other habitat types. However, there were indications of larger trees dying due to severe drought (Primack & Hall, 1992) which, combined with the low quality of soil present, may explain why some smaller trees with D.B.H. between 5 cm and 20 cm colonized this habitat. The alluvial sandy and humus peat soil characteristics of both medium and low closed heath forests of Bako National Park may also contribute to the smaller trees. However, some parts of the medium closed heath forest are characterized by three forms of forest strata (upper canopy stratum, middle canopy stratum, and lower canopy stratum) with emergent trees reaching more than 20 m high and D.B.H. class 70-74 cm. The common species of stand were from the families of Myrtaceae, Clusiaceae and Dipterocarpaceae with *Dipterocarp* spp. the most dominant stands. These tree families were prominent characteristics of forest structures in these ecosystems, and formed good canopy structure. A few had the open and far reaching branches that are suitable sleeping sites for the monkeys (Hon & Gumal, 2004). This indicated the quality of foraging habitat for Proboscis Monkey. Most of the monkeys' food plants are also sourced from these tree families (as described in Chapter6) (Bennett & Sebastian, 1988; Matsuda et al., 2009a; Salter & MacKenzie, 1981; Salter et al., 1985; Yeager, 1989a). Compared to other species, the densities of these food plants were higher at Lintang Trail, especially *Garcinia* sp., *Shorea* sp. at Paku Trail, *Whiteodendron* sp., *Syzygium* sp., and *Shorea* sp., and also at Tajor Trail, with *Whiteodendron* sp., and *Syzygium* sp. However the density of the preferred food plants especially *Syzygium* spp. and *Garcinia* spp. at Sibur Trail was very low. This may explain low population density of Proboscis Monkey compared to other primates (Han, 2001) in this secondary site. Overall, the density of preferred food plants, especially *Garcinia* sp., was higher in the medium closed heath forest compared to other study sites.

This forest has been a preferred habitat for Proboscis Monkey. A previous record on habitat use by Proboscis Monkey at Paku and Lintang Trails was high in this habitat (Salter et al., 1985) compared to other habitats in the park. It had a higher number of larger D.B.H. of trees compared to the low closed heath and the flooded forest. This habitat is close to water bodies, especially small streams at Teluk Assam, Teluk Tajor and Teluk Sibur and with the exception of Teluk Assam, easy arboreal access can also be obtained to the coastal mangrove nearby. Although canopy gaps occurred sparsely at Tajor Trail and Sibur Trail due to geographical factors, some very good canopy covers were evident, especially at Lintang and Paku Trails, compared to the low closed heath forest and the flooded forest. Generally, most of the canopies in the medium closed heath forest were in good health, very few were fair and only a number were of very poor condition.

The low closed heath forest of Pulau Lakei – Bako National Park, had no canopy gaps in the sampling units, however a number of canopy gaps surrounding the sampling plots were evident, suggesting that this habitat was unsuitable for the long-term survival of the monkeys. In addition, the incidence of fire damage to some food plants has deteriorated the quality of habitat. There were no larger trees available and the number of trees which could provide sleeping sites and crown cover were less than those within the medium closed heath and the flooded forests. This forest ecosystem is isolated and lacks a linking corridor to the mainland. Overall, the density of food plants was low suggesting a lower probability of occurrence of the monkeys in this isolated habitat (Marshall et al., 2009). This was evident where the monkeys were very hard to sight during this study.

In contrast, the flooded forest of Kuching Wetland National Park was occupied by a few larger and higher stands as opposed to the low closed heath forest, partly due to the presence of furtile soils. The forest stands grow on the lowland area with humus peat soil, and some parts were wet. The trees with D.B.H. class 10-14 cm constituted a major part of this habitat. It had no trees with D.B.H. larger than 44 cm. The forest strata were not clear and most of the stands were less than 10 m high. The poor tree canopies were minimal in this forest compared to the low closed heath forest. The structure and composition of forests which are characterized by some canopy gaps may affect the monkeys' foraging behaviour in relation to lower plant richness (Hopkins, 2011; Madden et al., 2010).

Although the flooded forest is a patchy fragment, it is composed of a few food plants especially from the families of Clusiaceae and Dipterocarpaceae. However, during this study Proboscis Monkey was observed more frequently foraging in the adjacent mangrove which tended to be their preferred habitat compared to this habitat. This explains that the monkeys have specific habitat requirements (Barton et al., 1992; Marshall, 2010) in relation to food availability (Arroyo-Rodríguez et al., 2008; Marshall et al., 2009).

This swamp or flooded forest habitat is facing rarely occurring but nevertheless ongoing disturbances such as illegal cutting of timber and collecting of other forest produce by the local people. This illegal cutting of timber has removed some larger trees and created some canopy gaps. As a result it was composed of a relatively high number of small trees compared to the medium closed heath forests. The changes that might have occurred due to this human disturbance may affect the habitat use of the monkeys (Pearson et al., 1999) and also their foraging success (Bissonette, 2003; Wilson et al., 2009). Thus, the fragmented habitat may also support the rare occurrence of the monkeys in this habitat as argued by Harper et al., (2008), however during the survey there were no monkeys sighted. Human disturbances will continue to occur as this monkeys' habitat is shared with inhabitants of the surrounding areas, with limited options for alternative sources of income. This problem could be incorporated into the park management strategies through a focus on tourism in the park as an alternate source of income for the local community.

Outside of this flooded forest habitat and outside the Kuching Wetland National Park in particular, dredged materials from land clearing for the construction of human settlements and infrastructure were discharged into the river system (Nyanti, Asikin, Ling, & Jongkas, 2012). Water quality in some parts of the river system and tributaries, including Sg. Salak, was reported to be very low (Rosli, Zawawi, & Bustami, 2012). The quality of water bodies is an important habitat attribute besides the forest structures that determine the quality of the monkeys' habitats.

Overall, the difference between habitat inside and outside the three study sites was evident with more subdivision of landscapes occurring outside the study sites. The differences among the study sites are related to the changes in forest structure and vegetation composition. The type and degree of disturbance that caused these changes also differed among the three habitats with the swamp or flooded forest the most disturbed habitat. The medium closed heath forest had more diverse stands with vertical gaps within the forest strata. Vertical gaps may lengthen arboreal routes if there is no choice of other alternate routes. These forest structures were not evident in the low closed heath forests and the flooded forests, however the low closed heath forests had better canopy connectivity than the flooded forest.

Human disturbance in the flooded forests has patterned the existing profile of stands, resulting in discontinuous connectivity among the crowns. Although the undergrowth has formed another layer of connectivity to facilitate arboreal routes, resource availability and diversity may not be sufficient for the long-term survival of the monkeys. The availability of resources in the flooded forests may be unable to provide all the foraging requirements for the monkeys (Curtis & Rasmussen, 2006) partly due to the quality of resources being diminished. The higher densities of certain food plants with higher basal area may not continue in perpetuity as the removal of trees is an ongoing process.

4.3.2 Mangrove Forest

The results presented here describe or outline the SU layout at Teluk Assam and Teluk Delima (Figure 4.9a) in Bako National Park, mangrove in Kuching Wetland National Park (Figure 4.9b), Selabat and near Bako High School (Figure 4.9c).

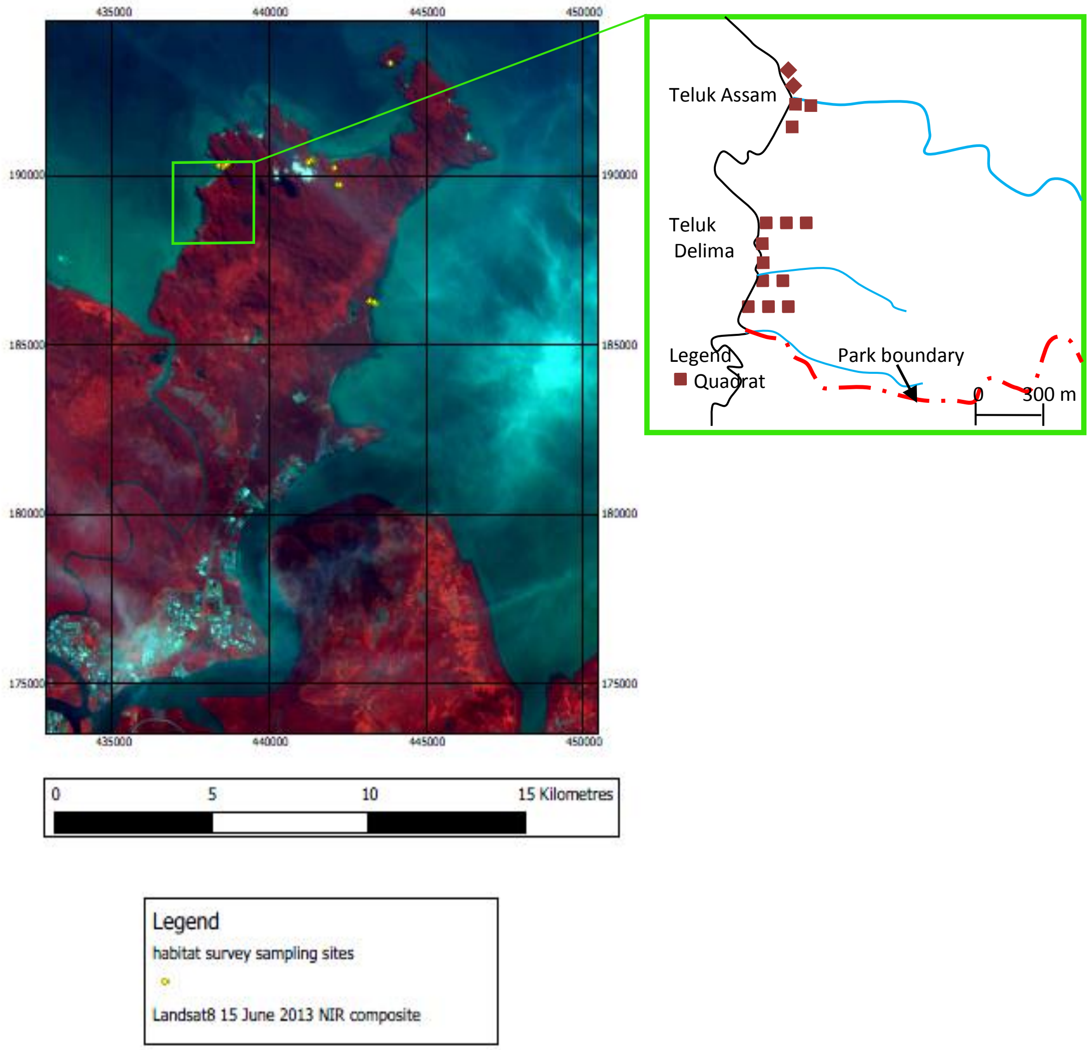


Figure 4.9a: Layout of sampling units in the coastal mangrove in Bako National Park

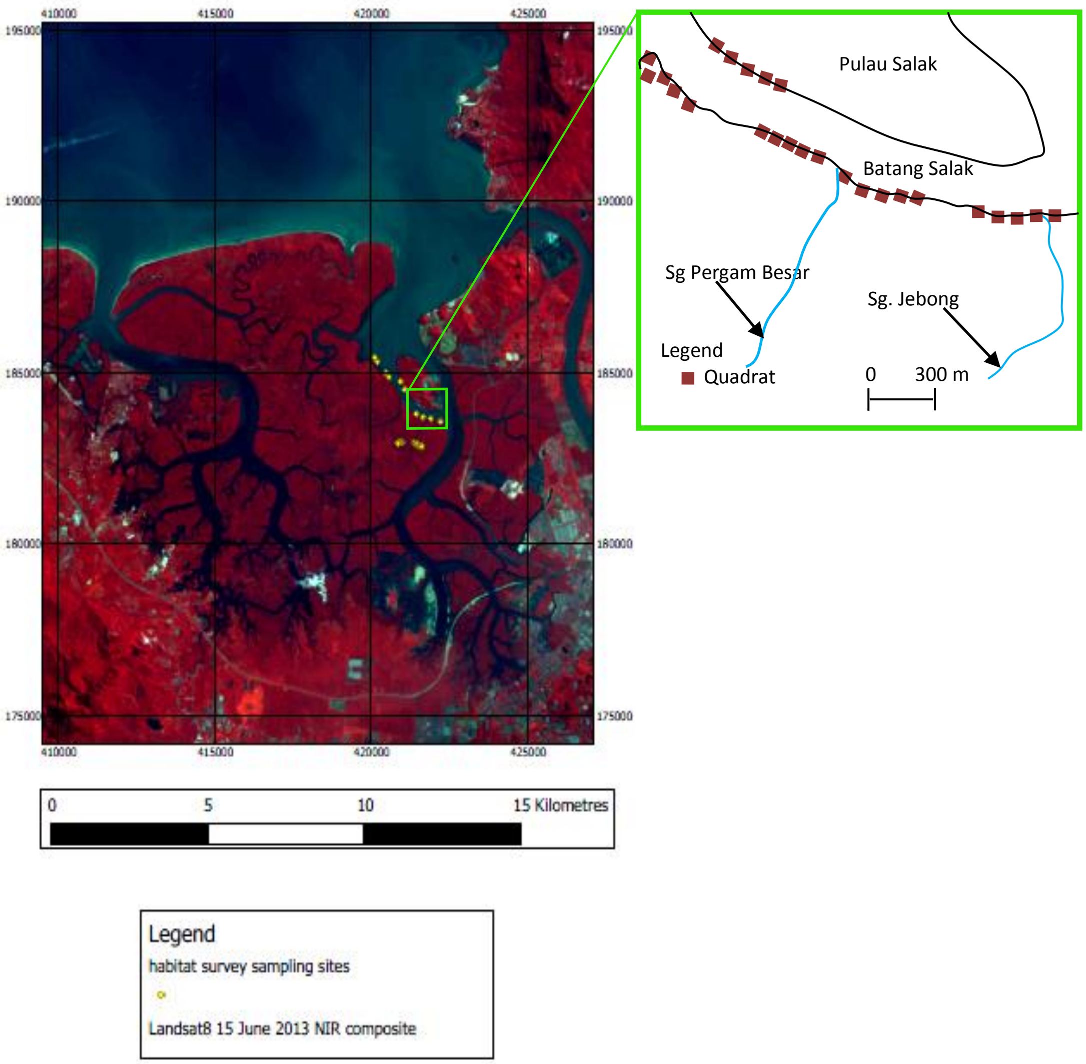


Figure 4.9b: Layout of sampling units in the riverine mangrove in Kuching Wetland National Park

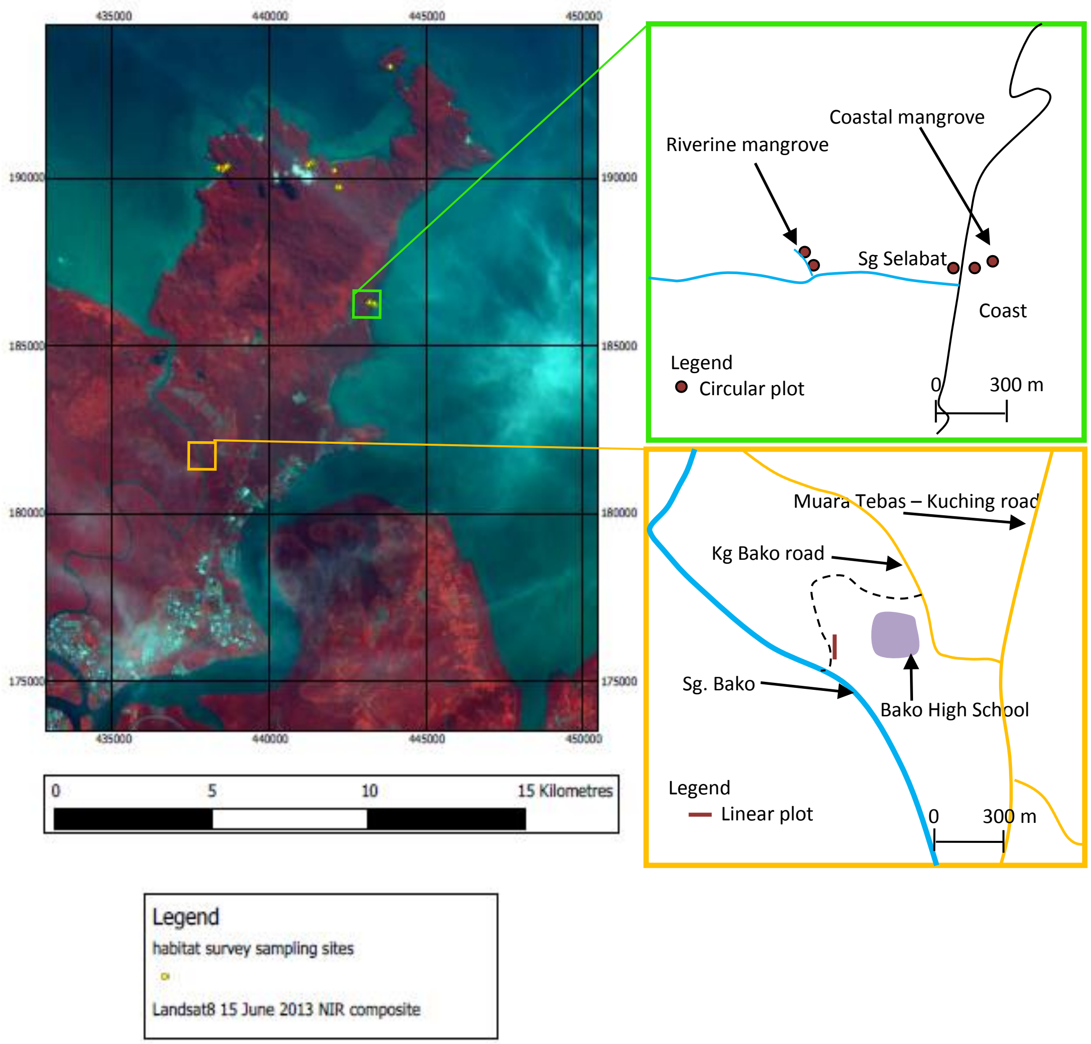


Figure 4.9c: Layout of sampling units in the coastal and riverine mangrove in Selabat and riverine mangrove near Bako High School

As shown in Figures 4.4 and 4.5 earlier in this chapter, landscape changes also occurred in and surrounding the study sites in mangrove forests. Changes to the landscape patterns mostly took place near coastal areas. As a result of these changes, quality mangrove habitats are fragmented and isolated. Coastal and riverine mangroves were dominated by trees with D.B.H. class 10-14 cm. Table

4.14a and Table 4.14b show the mean (±SD) values for each variable in both coastal and riverine mangroves. A number of mangrove stands in coastal areas were larger than riverine mangrove stands.

Table 4.14a: Summary statistics of variables in coastal mangrove

	Mean ± SD	Range
D.B.H. cm (n = 232)	16.30 ± 6.56	9.50 - 57.50
Height m (n = 232)	10.56 ± 4.54	2.50 - 22.00
Basal area (BA) m^2 (n = 232)	0.75 ± 1.24	0.18 - 12.98
Crown cover m (n = 10)	2.98 ± 1.36	1.00 - 5.00
Canopy gap m (n = 0)		
Number of branching trees (n = 1)	2.00	2.00 - 2.00
Distance from water body*m (n = 4)	30.00 ± 23.09	10.00 - 50.00
Number of tree which provides sleeping site (n = 2)	1.50 ± 0.71	1.00 - 2.00
Elevation m (n = 0)		
Slope % (n = 0)		

* river or coast

Table 4.14b: Summary statistics of variables in riverine mangrove

	Mean ± SD	Range
D.B.H.cm (n = 261)	15.51 ± 5.35	9.60 - 38.00
Height m (n = 261)	6.42 ± 1.73	3.50 - 12.50
Basal area(BA) m^2 (n = 261)	0.57 ± 0.46	0.20 - 2.84
Crown cover m (n = 16)	2.59 ± 1.78	1.00 - 6.00
Canopy gap m (n = 5)	5.70 ± 4.02	1.50 - 10.00
Number of branching trees (n = 8)	2.63 ± 1.06	2.00 - 5.00
Distance from water body*m (n = 3)	46.67 ± 47.26	10.00 - 100.00
Number of tree which provides sleeping site (n = 1)	1.00	1.00 - 1.00
Elevation m (n = 0)		
Slope % (n = 0)		

* river or coast

a. *Bako National Park*

Bako National Park has a limited area of mangrove forest. Teluk Assam and Teluk Delima are among the areas of coastal mangrove and are also the foraging habitat for Proboscis Monkey. Habitat structure of mangrove forest at Teluk Assam and

Teluk Delima was dominated by trees with D.B.H. class 10-14 cm (Appendix 6), however Teluk Delima contained more trees with larger D.B.H. compared to Teluk Assam. In addition, Teluk Delima was composed of trees with higher basal area (16.87 m^2 per ha). This suggests that Teluk Delima provides much better quality of habitat for the monkeys compared to Teluk Assam.

b. *Kuching Wetland National Park*

Riverine mangrove stands varied in D.B.H. and other variables. This ecosystem was mostly occupied by trees with D.B.H. class 10-14 cm and 15-19 cm (Appendix 6). Trees with D.B.H. class 10-14 cm were found in every SU, and was also the only D.B.H. class found in SU 13. This was due to the proximity of SU 13 to human settlements and the associated selective removal of some mangrove stands, leaving only smaller trees less than 14 cm D.B.H. The larger D.B.H. class of trees (35-39 cm) was enumerated from SUs between Sg. Jebong and Sg. Pergam. The monkeys were more frequently sighted in this area during this study, which suggests the quality of habitat, improved forest structure, and food resource availability between Sg. Jebong and Sg. Pergam in comparison to other secondary study sites in this mangrove habitat. The basal area of mangrove stands was also higher (13.48 m^2 per ha) in this area compared to other secondary study sites.

c. *Selabat Mangrove*

The Selabat mangrove, located at the Selabat coast and the Selabat river, represented both coastal and riverine mangrove. Variation in D.B.H. was evident for the coastal mangrove stands (Appendix 6) with more trees with larger D.B.H compared to the riverine mangrove. The highest D.B.H. class in the Selabat coastal mangrove was 55-59 cm whilst in the Selabat riverine mangrove was 25-29 cm. In the Selabat coastal mangrove, the highest basal area was 26.08 m^2 per ha and in the Selabat riverine mangrove was 8.34 m^2 per ha. Apart from this the Selabat coastal mangrove had more different classes of D.B.H. compared to the Selabat riverine mangrove. This illustrates that the Selabat coastal mangrove had better representation and distribution of D.B.H. compared to the Selabat riverine mangrove.

d. *Bako High School Mangrove*

Bako High School mangrove as depicted in Appendix 6 was a small pocket of riverine mangrove stands near the school. This SU only contained trees with D.B.H. class 10-14 cm and 15-19 cm, with a higher number of the former class than the latter. Mangrove stands were almost the same age with a basal area of 9.37 m^2ha^{-1}.

Plant Species Recorded

A listing of species recorded in these mangrove forests is shown in Appendix 7. Most of these mangrove species are food plants for Proboscis Monkey.

a. *Bako National Park*

Teluk Assam was colonized by *Rhizophora apiculata, Avicennia alba, Avicennia marina*, and *Bruguiera* sp. as shown in Figure 4.10a. Among these four species, *Rhizophora apiculata* was the most abundant (90 trees per ha). Teluk Delima (Figure 4.10b) was occupied by *Sonneratia alba, Rhizophora apiculata, Avicennia marina,* and *Avicennia alba.* The density of *Sonneratia alba* at Delima was 390 trees per ha which was higher than any other species within both study sites.

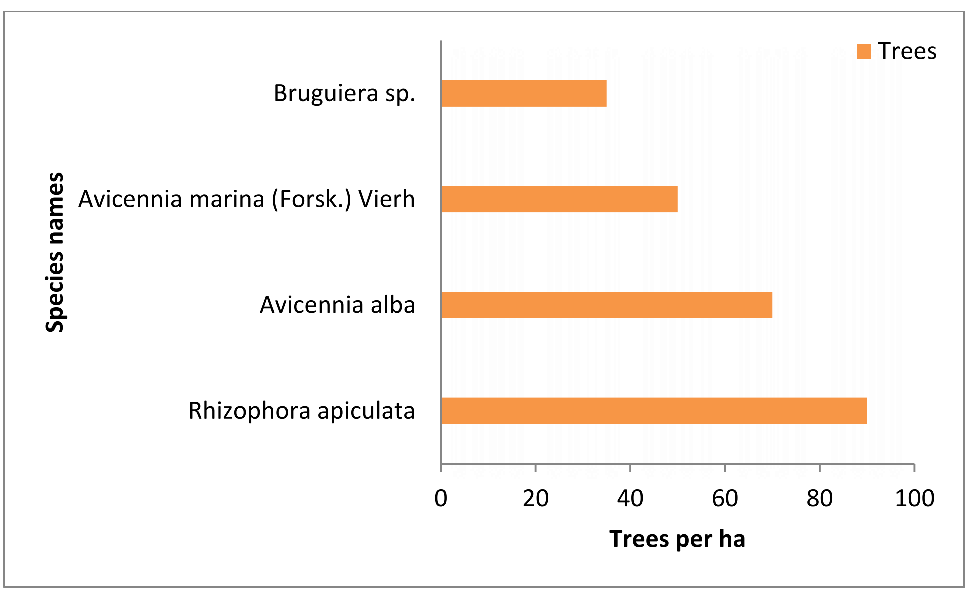


Figure 4.10a: Species abundance from SU at Teluk Assam

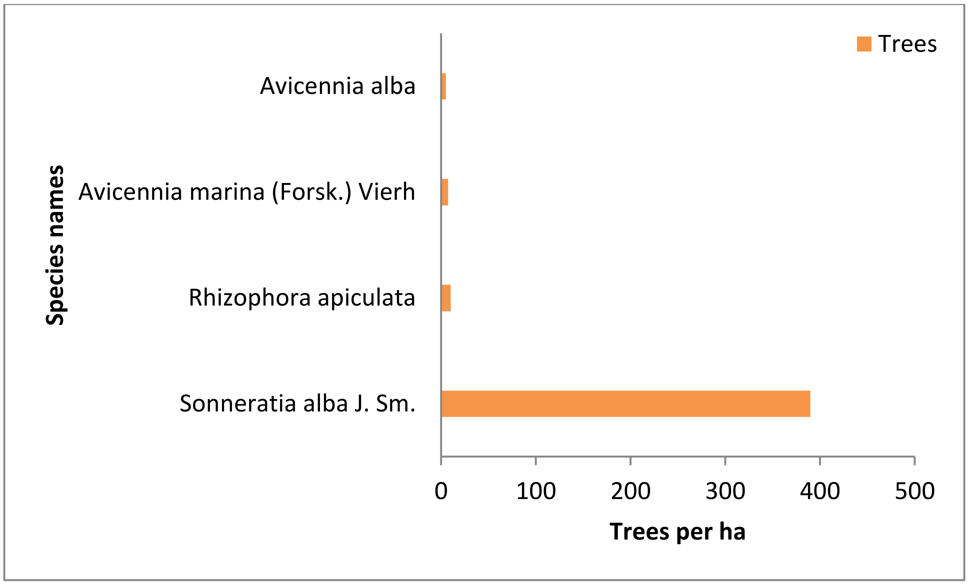


Figure 4.10b: Species abundance from SU at Teluk Delima

b. *Kuching Wetland National Park*

Avicennia sp. was the most abundant species with a density of 190 trees per ha compared to other mangrove species in SUs at Sg. Jebong (Figure 4.11a). *Sonneratia alba* represented 50 trees per ha, *Rhizophora mucronata* 30 trees per ha and *Rhizophora apiculata* only 5 trees per ha. *Sonneratia alba* was the most abundant species at Sg. Pergam Besar (Figure 4.11b), Pulau Salak (Figure 4.11c), Sg. Pergam Kechil (Figure 4.11d), and Sg. Enggang (Figure 4.11e), which accounted for 250, 240, 180, and 870 trees per ha respectively. The other species at these four sites was *Avicennia* sp. but its representation was very little. Overall, the study sites were dominated by *Sonneratia alba.*

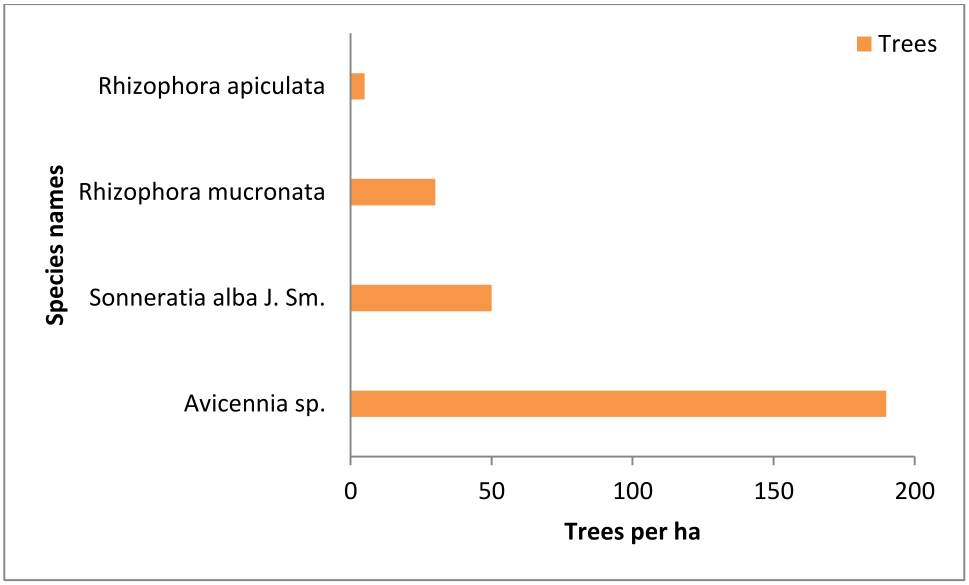


Figure 4.11a: Species abundance at Site 1 Sg. Jebong

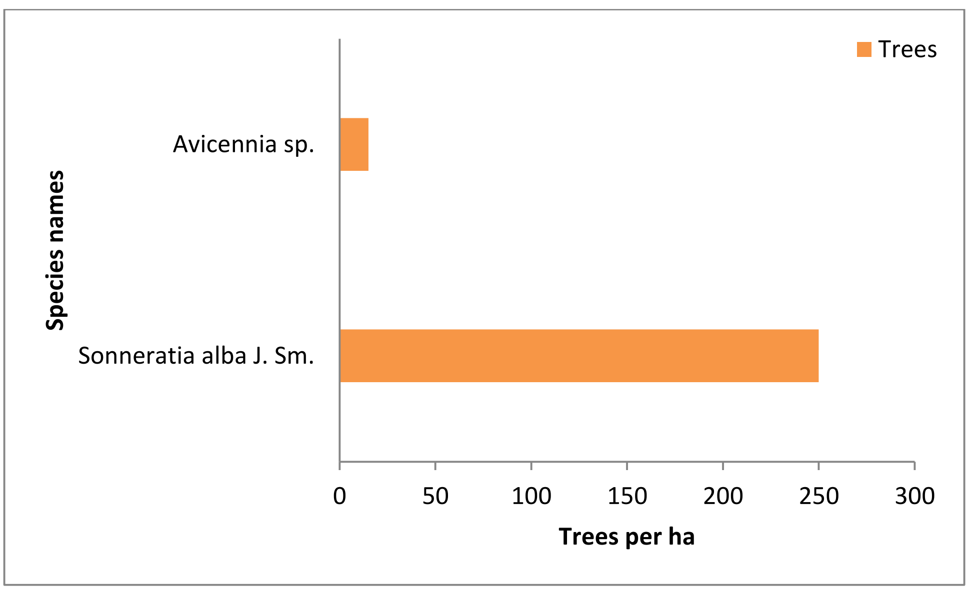


Figure 4.11b: Species abundance at Site 2 Sg. Pergam Besar

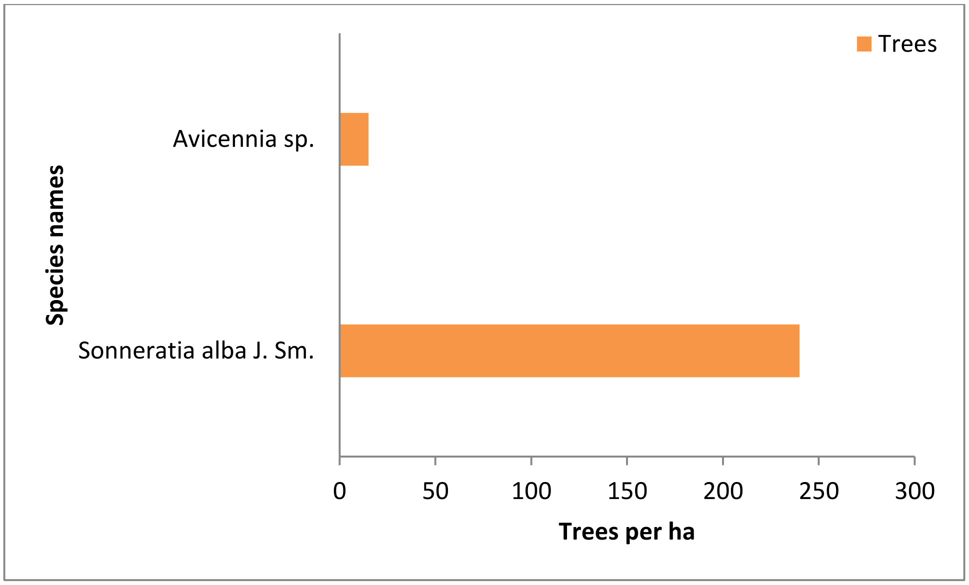


Figure 4.11c: Species abundance at Site 3 Pulau Salak

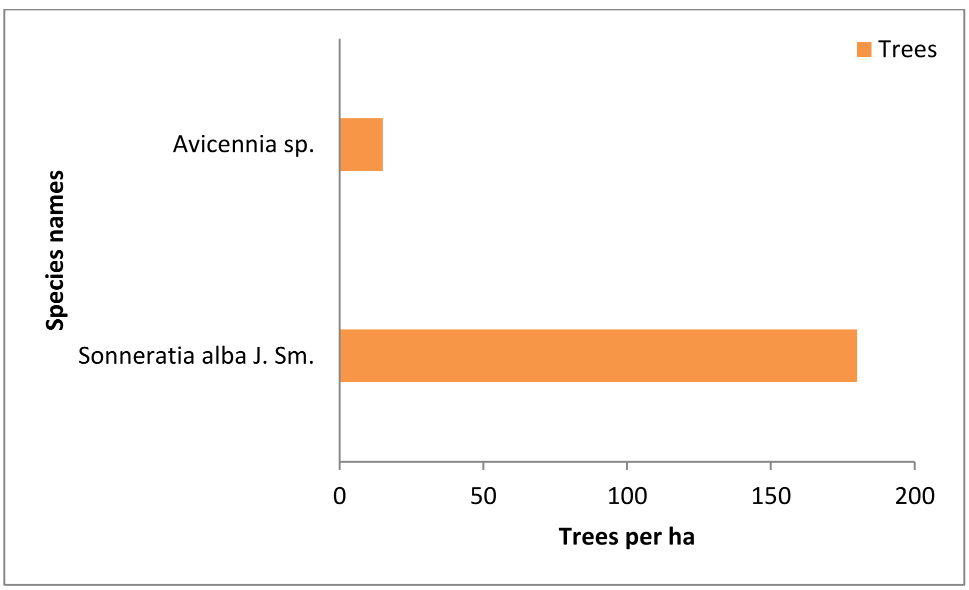


Figure 4.11d: Species abundance at Site 4 Sg. Pergam Kechil

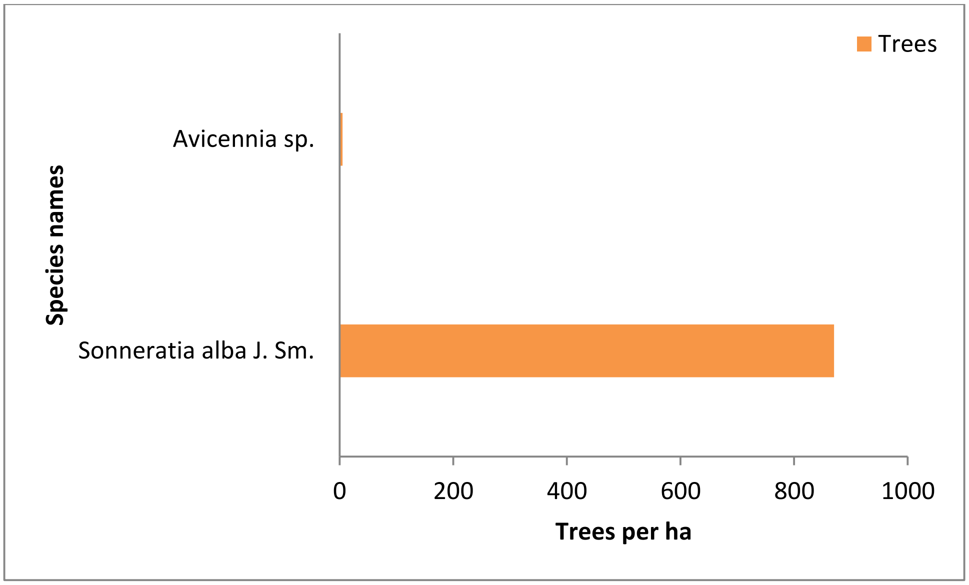


Figure 4.11e: Species abundance at Site 5 Sg. Enggang

c. *Selabat Mangrove*

Sonneratia alba was exclusively abundant in the Selabat coastal mangrove (Figure 4.12a), which accounted for 300 trees per ha. Its representation at Site 2 in riverine mangrove was also 300 trees per ha compared to *Avicennia alba* which represented 100 trees per ha (Figure 4.12b). At Site 3 in riverine mangrove (Figure 4.12c) both *Sonneratia alba* and and *Avicennia alba* had equal representation (150 trees per ha respectively).

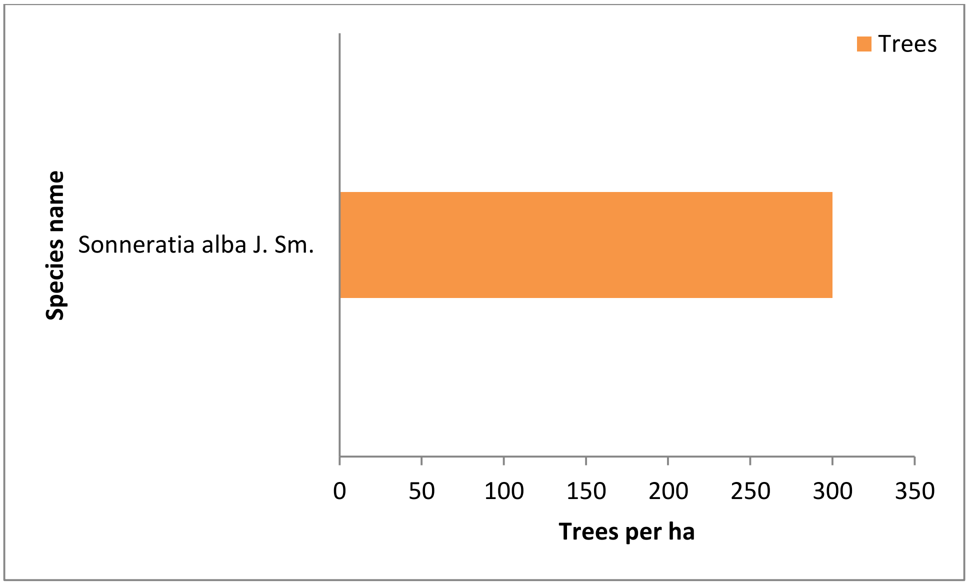


Figure 4.12a: Species abundance at Site 1 coastal Selabat

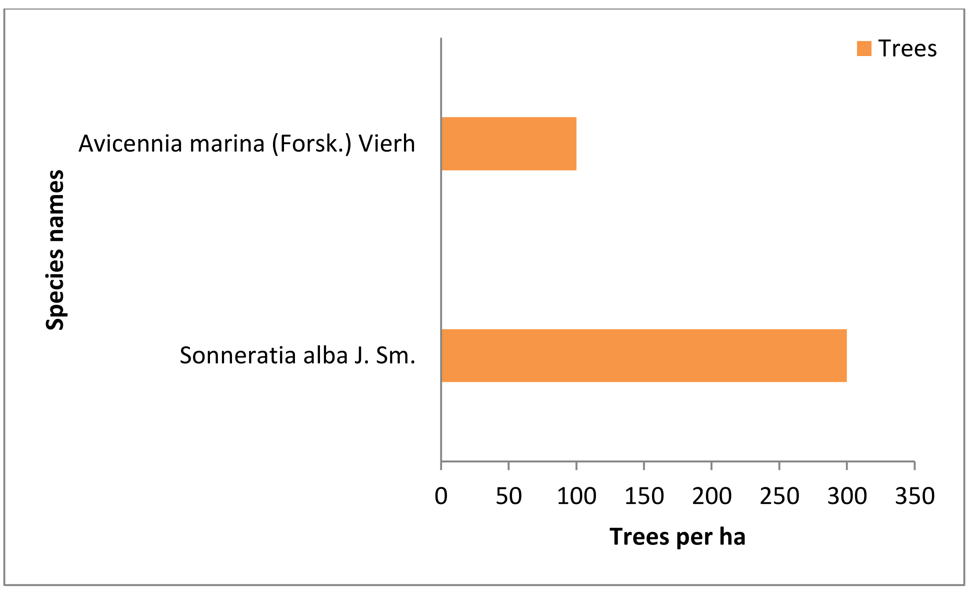


Figure 4.12b: Species abundance at Site 2 riverine Selabat

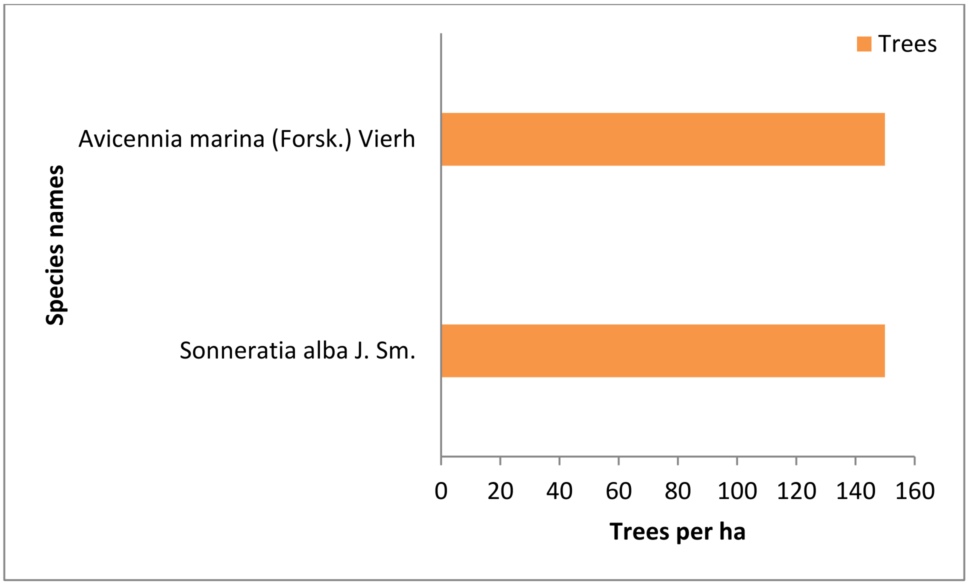


Figure 4.12c: Species abundance at Site 3 riverine Selabat

d. *Bako High School Mangrove*

Riverine mangrove at Bako High School was exclusively dominated by *Avicennia* sp. Its representation in this area was 850 trees per ha (Figure 4.13). Nonetheless, *Avicennia* community was a tiny mangrove fragment surrounded by land clearing.

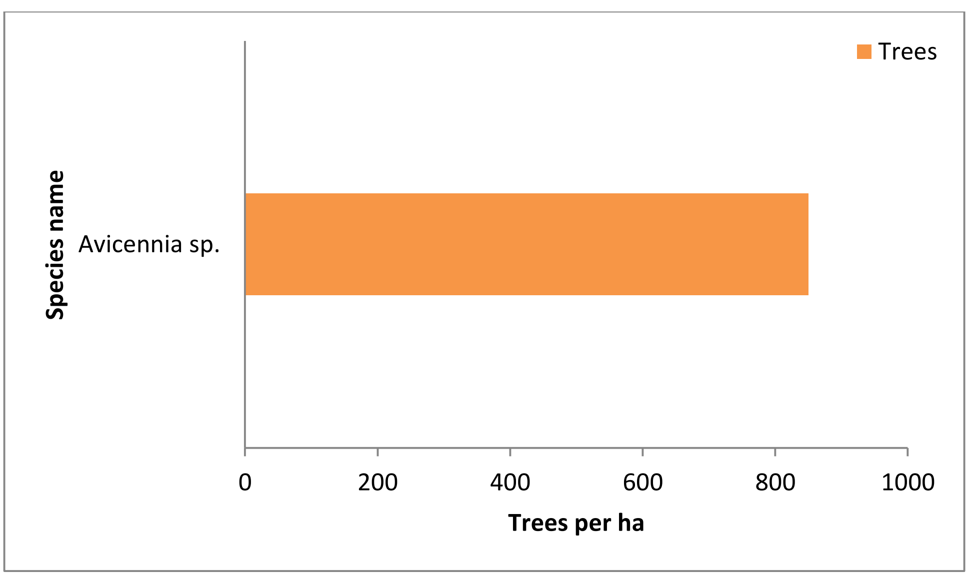


Figure 4.13: Species abundance behind Bako High School

Tree Profile

a. *Bako National Park*

Trees in SUs at Teluk Assam were not all in good health (Appendix 8). A number of canopy gaps were evident with uneven form of canopy layers. The dense canopies with good connectivity were found in SUs located further inland and uneven age of stands was evident. This habitat is exposed to erosion and some species have been washed out due to the strong tidal waves from the sea. The succession process had been taking place and the colonization of young mangrove species was evident. Mangrove stands at Teluk Delima also showed uneven form of canopy layers. But the tree canopies in this habitat were denser than tree canopies at Teluk Assam. The stands had good crown health with less canopy gaps compared to the stands at Teluk Assam. This suggests the habitat at Teluk Delima was much better than Teluk Assam with little changes in the stand composition and structure.

b. *Kuching Wetland National Park*

The profile of stands in this habitat also varied (Appendix 8). SU 1 which was located in the secondary site 1 between Sg. Jebong and Sg. Pergam had much shorter mangrove stands compared to stands in other secondary study sites. However, fairly good connectivity with less canopy gap was evident which provided a good arboreal route for the monkeys. The tree structure and composition were not much changed, suggesting that less disturbance occurred in this study site. A number of SUs had stands with good connectivity and no canopy gap especially SU 2, SU 3, SU 4, SU 5, SU 6, SU 7, SU 8, and SU 11. These SUs were located near Sg. Pergam, the area where the monkeys were most frequently sighted in this study. SUs located far from Sg. Jebong and Sg. Pergam had fairly good connectivity and some canopy gaps were evident especially SU 9, SU 10, and SU 12 in the secondary site 2.

In the secondary site 3, SU 13 was occupied by a very uniform canopy cover with stands of similar age. Crowns were connected with one another and formed good connectivity with no canopy gap. Crown patterns were slightly uniform in SU 14 because not many trees in the same age. But connectivity was well established and no canopy gap. Trees with almost the same age were illustrated in SU 15. Canopy gap was absence and connectivity was formed among the trees. This secondary site 3 had less human disturbance but there was a sign of erosion on the forest floor which may due to the strong tidal movement in the Salak river.

The forest structure and composition were also not much changed in the secondary site 4 and 5. A slightly uneven canopy but no canopy gap and good connectivity were evident in SU 16, and SU 17. Other SUs in these secondary sites showed moderately good canopies of trees. Some canopy gaps were evident as these SUs had a number of trees which had died back. Overall, the connectivity in this habitat was fairly good.

c. *Selabat Mangrove*

Mangrove trees were too few to form connectivity in SUs at the secondary site 1, 2 and 3 near the coast (Appendix 8). This had created large canopy gaps. More mangrove stands were enumerated from SU 4 in the riverine mangrove as this secondary site 4 was composed of young trees with small crowns. In contrast, a larger gap was present in the riverine mangrove in the secondary site 5, which was located further inland, suggesting the quality of this habitat was poor. In addition, tree structure and composition had been seriously altered with only shorter trees present.

d. *Bako High School Mangrove*

Mangrove stands in SU 1 at Bako High School were almost the same age. A number of trees had smaller crowns and the others had larger crowns with a number of small gaps along the transect line (Appendix 8). The relative health of the mangroves was poor and not suitable for long-term survival of the monkeys. Moreover, the surrounding habitats were fragmented and loss of mangrove species diversity was evident.

Proboscis Monkey and Other Species Occurrence

Table 4.15 shows the occurrences of Proboscis Monkey and other species of wildlife in the study sites. The occurrences of Silvered Langur and Long-tailed Macaque were less frequent compared to Proboscis Monkey in mangrove forest.

Table 4.15: Species of wildlife sightings in the mangrove forests of the study sites

Wildlife	Site	Literature	This study	Local people
Proboscis Monkey	BNP	September 2005	June 2013	June 2013
	KWNP	December 2008	June 2013	June 2013
	Selabat			April 2012
	BHS			June 2013
Silvered Langur	BNP		November 2011	November 2011
	KWNP	December 2008	May 2012	May 2012
Long-tailed Macaque	BNP		June 2013	June 2013
	KWNP	December 2008	May 2012	January 2012
	BHS			April 2012
Crocodiles	KWNP	December 2008	May 2012	

Proboscis Monkey was frequently sighted at Teluk Assam, Teluk Delima in Bako National Park and the area between Sg. Jebong and Sg. Pergam opposite Kg. Pulau Salak in Kuching Wetland National Park. During this study Proboscis Monkey was sighted from June 2011 to May 2012. Frequency of sightings of Silvered Langur at Teluk Assam in Bako National Park and Kuching Wetland National Park was less than monthly. However Long-tailed Macaque was sighted almost every month at Teluk Assam and on a rare occasion was found in Kuching Wetland National Park. Information on the monkeys at Selabat was obtained from Selabat village folks, whereas at Bako High School information was sourced from Bako folks. A group of Proboscis Monkey at Selabat may be the same group found at

Bukit Gondol in Bako National Park as there is a corridor linking the park with Selabat.

Discussion

Mangrove ecosystem cannot be compared with other forest ecosystems in the study sites as this habitat is ecologically different from the low closed heath forest, the medium closed heath forest, the flooded and the swamp forests. The coastal mangrove was composed of a number of larger trees and its basal area of trees was higher as opposed to the riverine mangrove. Both habitats are composed of *Sonneratia alba* community that is a highly preferred food of Proboscis Monkey. A previous study on the ecology of Proboscis Monkey was mostly conducted in coastal mangrove (Bennett & Gombek, 1993; Bennett & Sebastian, 1988; Meijaard & Nijman, 2000a) and riverine mangrove (Boonratana, 2000; Matsuda et al., 2010; Matsuda et al., 2009b; Yeager, 1991b) suggesting that these habitats are the most preferred habitats for the monkeys. The occurrence of the monkeys in other riverine habitats (Sha et al., 2008) may have been partly due to human disturbance and availability of food resources. Human disturbance in the form of land clearing and exploitation of mangrove trees was more evident outside the study sites as shown in the satellite imagery during this study. Thus, the quality of mangrove habitats outside the study sites was very low. This was due to most of the infrastructure development occurring near the coastal and riverine mangroves (Meijaard & Nijman, 2000a) which resulted in fragmentation, subdivision, and isolation of landscapes (Bismark, 2010; Lindenmayer & Fischer, 2006). As Proboscis Monkey is arboreal primate (Bennett & Gombek, 1993) landscape modification that leads to fragmentation is not suitable for these monkeys. High canopy connectivity is very important to arboreal primates because its permit safe and easy travel between patches (Boubli, Couto-Santos, & Strier, 2011).

Teluk Assam and Teluk Delima are colonized by a small pocket of coastal mangrove. The mixture of mangrove species is more diverse at Teluk Assam compared to Teluk Delima. But most of *Sonneratia alba* outside the sampling units at Teluk Assam is dying which leads to poor connectivity. This had also been noticed from the satellite imagery in 2005 and 2013. Sedimentation was evident where the mangrove floor was covered full by sand. This is a common environmental phenomenon in mangrove ecosystem (Saad, 1996) that has been associated with the killing of pneumatophores (Ellis et al., 2004; Gilman, Ellison, Duke, & Field, 2008). Proboscis Monkey was most frequently observed in this habitat suggesting that this mangrove habitat was their preferred foraging habitat. The existing boardwalk has facilitated the tourists observing the monkeys and accessing the heath forest. Geographically and ecologically these mangrove stands cannot colonize further inland as they are hindered by the cliffs.

In Teluk Delima, proper crown connectivity was evident among the evenly formed canopy layer and the canopy gaps were not too large, such that they provided an easy arboreal access. This prominent characteristic of mangrove habitat may provide a quality of habitat as the mangrove composition has not seriously changed besides the abundance of preferred food plants from the family of Sonneratiaceae. The availability of high quality food resources among the preferred food plants are indicators that determine the survival of primates (Curtis & Rasmussen, 2006; da Silva Junior et al., 2010). Apart from this, less human disturbance occurred at Teluk Delima and there was also very little sign of erosion on the forest floor because this habitat is located far from the sea compared to Teluk Assam.

In contrast, mangrove at Bako High School was a subdivided and isolated patch which was surrounded by infrastructure development. This poor habitat contained very limited food resources and plant richness to sustain the population density of the monkeys (Cristóbal-Azkarate & Arroyo-Rodríguez, 2007). The ongoing disturbance surrounding the sampling unit in the form of land conversion may cause local extinction of the monkeys as has been experienced in Pulau Kaget, Indonesia (Meijaard & Nijman, 2000b). In Selabat, there was no disturbance in the vicinity of sampling units. The structure and composition of coastal mangrove was better than riverine mangrove. Its pole size was larger than the riverine mangrove which formed a good protection to the shores from tidal waves. A lot of pneumatophores of *Sonneratia alba* were present on the sandy-muddy ground suggesting the stands were in good health. However, the mangrove ecosystem outside the study site is subject to anthropogenic disturbance. The northern part of Selabat is occupied by human settlements and aquaculture farms. This aquaculture farming is a small industry and may not seriously affect the quality of habitat for the monkeys. However, conversion of mangrove habitat for aquaculture farming is not a good practice because this kind of farming can be situated elsewhere, such as further inland or in the designated rivers by the authority. At present, a few aquaculture farms were abandoned and the extent of disturbance is manageable but if sewerage systems from nearby settlement areas are not properly managed, these issues will eventually affect the quality of mangrove ecosystem.

Mangrove habitat in this region was very much reduced as shown in the satellite imagery from 2013, in particular Bako High School mangrove which is likely to disappear at any time. Modification of mangrove habitat near Selabat and Bako High School may eventually lead to habitat loss. Within government lands there was a revegetation initiative of the Forest Departmentof Sarawak to enrich mangrove ecosystem. This mangrove restoration programme commenced in 2006 and as of 2009 about 130,500 seedlings were planted in 87 ha of riverine area (Afendi et al., 2009) including at Selabat. The programme continued till 2010 when about 508,197 mangrove species were planted in 283.8 ha area. Of this, 3,000 mangrove seedlings were planted in a 6 ha area of Kuching Wetland National Park (FDS, 2010b). As the seedling survival rate was high, especially in the areas that were not exposed to the strong tidal waves, it is worthwhile to extend the area of coverage by planting species that are preferred food plants of the monkeys especially *Sonneratia alba*.

The riverine mangrove stands in Kuching Wetland National Park were healthier than those in Teluk Assam, Teluk Delima, Selabat and Bako High School. *Sonneratia* stands form a stretch of mangrove habitat between the Sg. Pergam and Sg. Jebong where Proboscis Monkey was frequently sighted. The density of *Sonneratia* sp. especially at Sg. Enggang was higher compared to other secondary study sites. Most of the tree canopies formed fairly good connectivity which explains the limited disturbance ofthis mangrove. The composition of mangrove trees in the sampling units was not much changed besides an abundance of food plants. This riverine mangrove habitat is suitable for the monkeys as it provides all the requirements for the monkeys to survive. Overall, canopy strata were not evident in some parts of the study sites because they were mostly colonized by even stands. However, the fairly good connectivity formed by the high canopy of these even stands may provide safe arboreal routes to Proboscis Monkey, thus reducing the risk of predation.

4.3.3 Swamp Forest or Peat Moss Forest

The sites were mostly flooded by water and the SUs as depicted in Figure 4.14 were established along the existing jungle paths created by local people for extracting timber and forest produce. Surveying was only carried out during high tide using a small boat mounted by a 25 horse power engine. The selection of secondary sites and the design of SUs took into account reducing edge effects on the data collection.

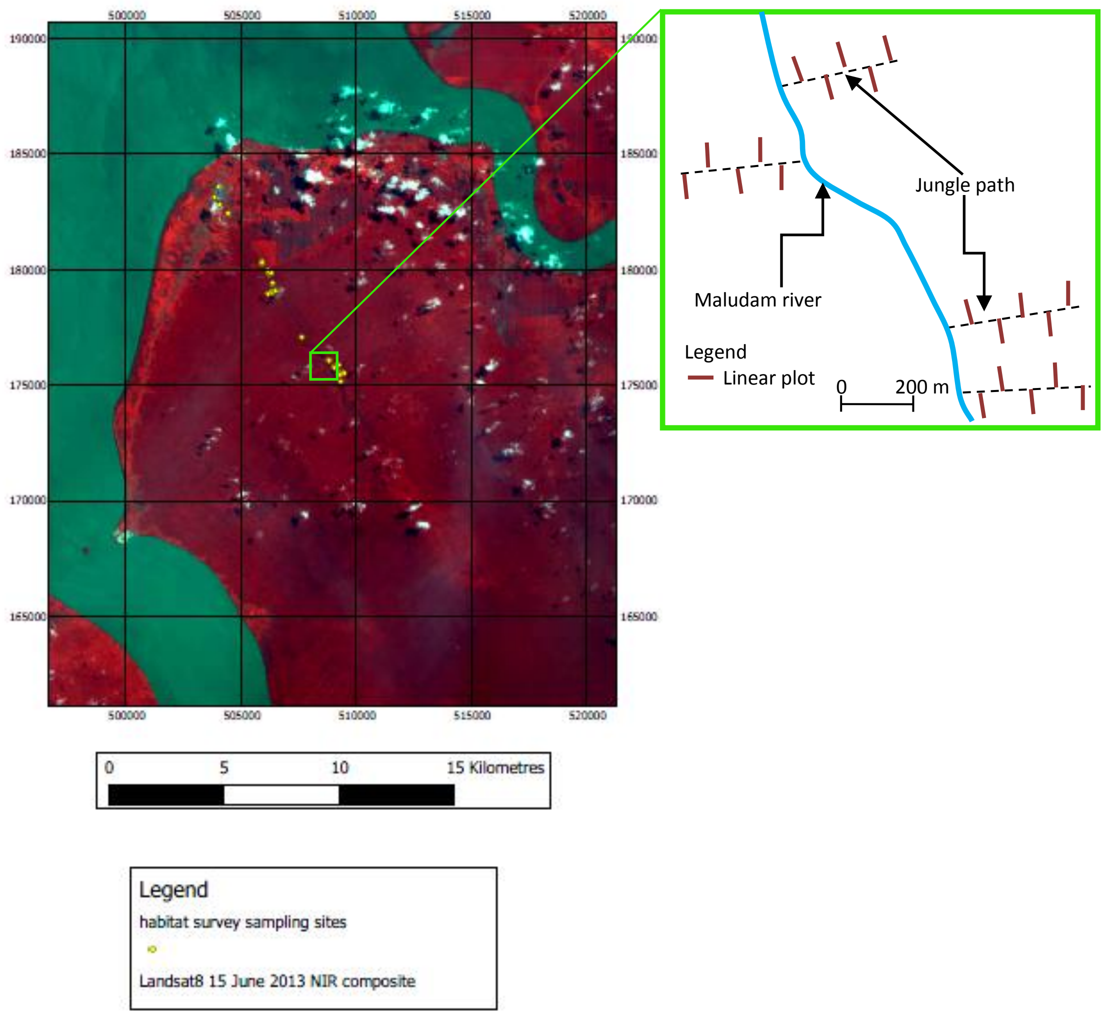


Figure 4.14: Fishbone design of sampling units in Maludam National Park

From the satellite imagery, some post-harvesting tracks were still evident in 2005 however by 2013 (during this study) these tracks were almost covered by canopies through processes of succession and recruitment (Figure 4.15). In contrast, in 2013 the landscape matrix surrounding the park had expanded, especially those near settlement areas which lead to fragmentation. There has also been a recent clearing of cut lines at the nearby agriculture plantation and this clearing was expanded into the park. These cut lines inside the park affect the quality of habitat for the monkeys because they have created forest gaps that form poor connectivity.

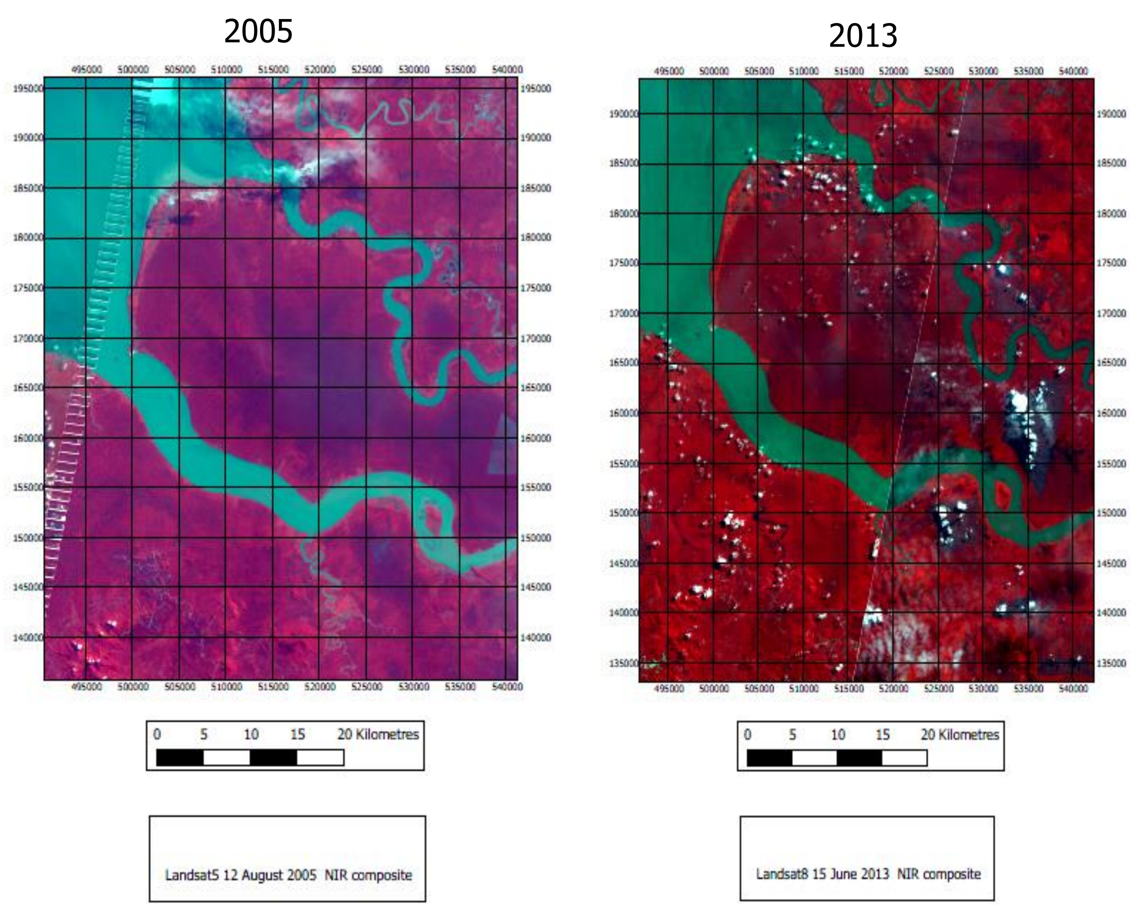


Figure 4.15: Landscape patterns in the study sites – Maludam National Park

This habitat is a secondary swamp forest covered by small stands with mostly less than 40 cm D.B.H. The data on D.B.H. showed that the majority of trees were between 10 and 20 cm and their height were less than 10 m. Mean (±SD) values for the sample variables are shown in Table 4.16. Total number of trees sampled was 435 with the larger D.B.H. being 96 cm and the highest tree was 17 m.

Table 4.16: Summary statistics of variables in swamp forest

	Mean ± SD	Range
D.B.H. cm (n = 435)	20.52 ± 11.51	10.00 - 96.00
Height m (n = 435)	7.99 ± 3.66	2.00 - 17.00
Basal area (BA) m^2 (n = 435)	2.17 ± 3.43	0.39 - 36.19
Crown cover m (n = 53)	3.64 ± 1.98	1.00 - 10.40
Canopy gap m (n = 15)	7.21 ± 5.69	1.00 - 19.50
Number of branching trees (n = 38)	2.47 ± 1.39	2.00 - 8.00
Distance from water body*m (n = 20)	45.00 ± 21.15	10.00 - 90.00
Number of tree which provides sleeping site (n = 9)	2.55 ± 1.13	1.00 - 4.00
Elevation m (n = 20)	6.25 ± 1.12	5.00 - 8.00
Slope % (n = 0)		

* river or coast

All the four secondary sites in this habitat differed in the number of trees with certain D.B.H. class (Appendix 9). Although there was a tree reaching 94 cm D.B.H. in SU 13, due to past logging of larger trees this habitat had more small trees and only a few large trees. Some seedling cover on the forest floor indicated an ongoing recruitment process. Both D.B.H. class 10-14 cm and 15-19 cm had dominated all the SUs. The larger trees were found in SUs located at the upper Maludam river. The higher basal area (99.49 m^2 per ha) was recorded from SU 13 which had trees with larger D.B.H. class and the lower basal area (16.16 m^2 per ha) was recorded from SU 5 which had more trees with smaller D.B.H. class.

Plant Species Recorded

A listing of species recorded at the sites is shown in Appendix 10. A few of these species were food plants for Proboscis Monkey. Species abundance in Figure 4.16a shows that *Syzygium* sp. was dominant in the secondary site 1 with 280 trees per ha. *Ilex* sp. represented the second largest number oftrees with 170 trees per ha. In the secondary site 2, *Syzygium* sp. was also dominant with 150 trees per ha compared to *Ganua* sp. with 120 trees per ha (Figure 4.16b). The secondary sites 3 (Figure 4.16c) and 4 (Figure 4.16d) on the other hand were dominated by *Ilex* sp. with 410 and 300 tress per ha respectively. The secondary sites 3 and 4 were located at the upper river compared to the secondary sites 1 and 2. *Ganua* sp. and *Syzygium* sp. with respective 150 trees per ha were the second dominant trees at the secondary site 3. *Syzygium* sp. on the other hand represented 220 trees per ha at the secondary site 4.

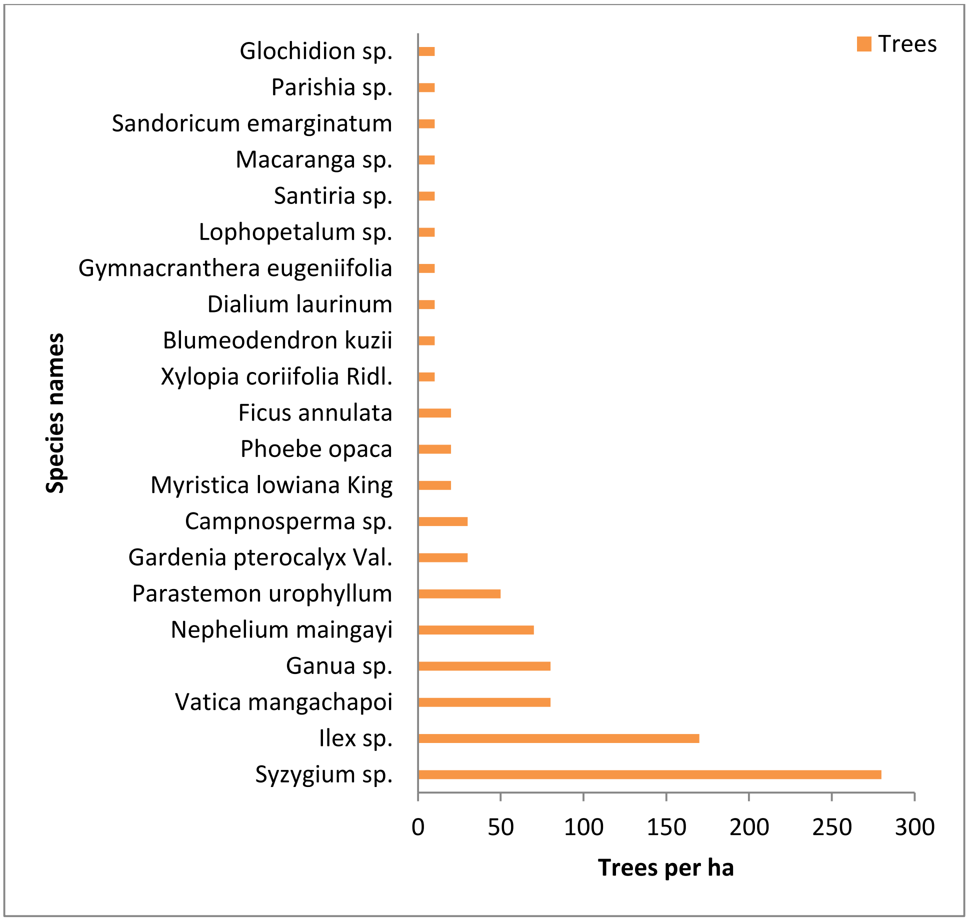


Figure 4.16a: Species abundance at Site 1 (east side of river)

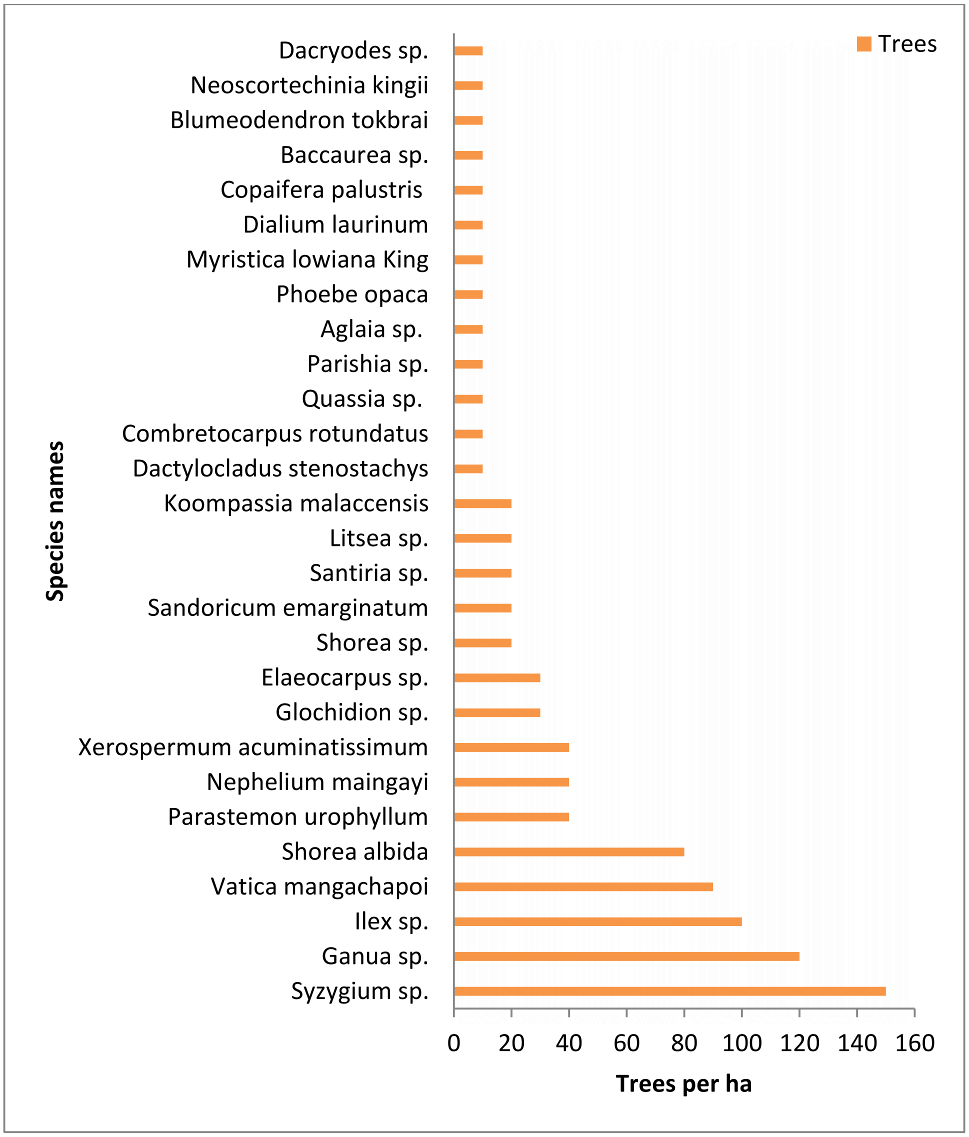


Figure 4.16b: Species abundance at Site 2 (west side of river)

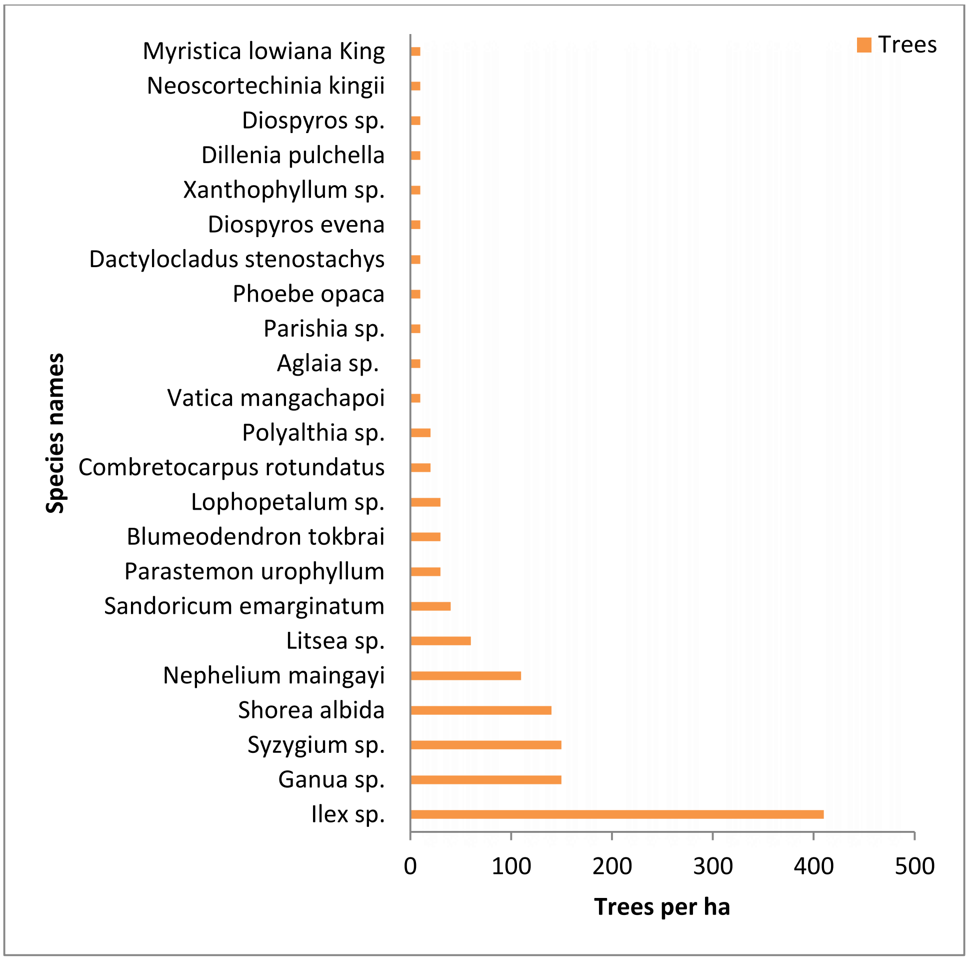


Figure 4.16c: Species abundance at Site 3 (east side of river)

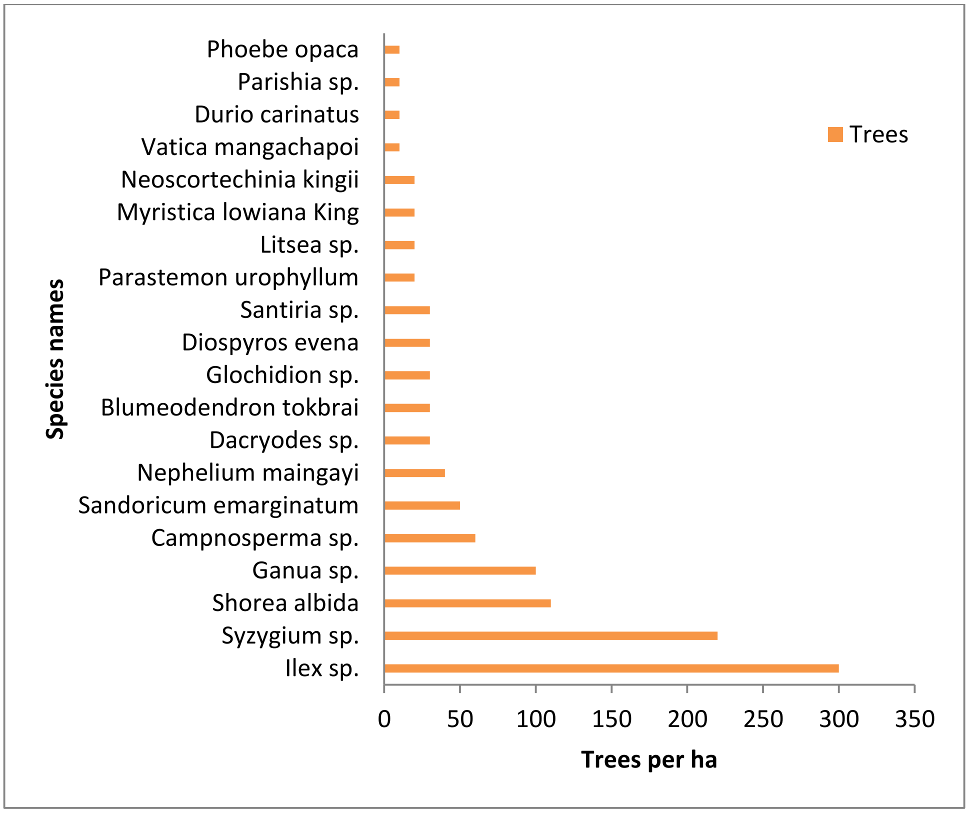


Figure 4.16d: Species abundance at Site 4 (east side of river)

Tree profile

The profile of trees in all SUs in this habitat showed the forest structure and composition were seriously changed (Appendix 11). Considerable variation in height and crown size was evident among the four secondary sites. Despite the presence of canopy gaps, canopy connectivity in the secondary sites located on the upper river was good. In the secondary site 1, the four SUs had canopy gaps. Although good canopy cover was detected along the transect lines, the connectivity outside the SUs was poor. There were only four trees on the transect line in SU 1 with canopy gaps of 8 m long. Average length of crown cover for the four trees on the transect line was 3.2 m but connectivity was good. Similarly, trees in SU 2 were sparsely distributed, and height and crown sizes varied. A number of canopy gaps were present with only three trees on the transect line. Crown health of one of these trees was poor and others fairly good and good. There was good canopy connectivity along the transect line. The majority of trees in SU 3 were shorter and only a number were taller. All four trees on the transect line had good crown health and average crown cover was 5 m. The presence of canopy gaps was minimal and connectivity was good. In SU 4 there were four trees on the transect line with average length of crown cover being 3.3 m. Crown heath for one of the trees on the transect line was good and the rest were fairly good. Canopy gaps of 4.6 m long were present but connectivity was fairly good. On the other hand SU 5 had a number of smaller trees which were sparsely distributed. On the transect line there were three trees with average length of crown cover 2 m. One of these crowns was in good condition and the restwere in fairly good condition. Canopy gaps were present and connectivity was slightly poor.

In the secondary site 2, some canopy gaps were detected. This site was mostly dominated by some shorter stands. This was evident in SU 6 which was composed of a number of smaller trees with only two trees on the transect line whose crowns were both poor and fairly good. Crown cover was only 6.5 m long and as a result a 14 m long section of canopy gap was present on the transect line. In addition connectivity was slightly poor. SU 7 showed sparse distribution of small trees with three trees on the transect line. Crown health for these three trees was poor. A canopy gap of 19.5 m long was present on the transect line suggesting poor connectivity. The profile of trees in SU 8 showed a clumpy distribution of forest stands. There were three trees on the transect line with both good and fairly good crown health. A large canopy gap of 15 m long was present on the transect line which resulted in poor canopy connectivity. Poor connectivity was also present in SU 9 with canopy gaps of 5 m long. Trees in SU 10 varied in height and sparsely distributed with more small trees present. Of three trees, one had a crown in good health and the other was fairly good. A canopy gap of 6 m long was present on the transect line suggesting a poor arboreal route for Proboscis Monkey.

The secondary site 3 was colonized by trees of various height. There was only one tree on the transect line however a 5 m long canopy gap in SU 11 resulted from tree branches from outside also coverering the transect line. Connectivity was fairly good. SU 12 had 1 (one) m long of canopy gap on the transect line, although height of trees were uneven. Its canopy connectivity was fairly good. In SU 13 there was a canopy gap of 5.6 m long on the transect line with fairly good connectivity. Connectivity was good in SU 14 although there was only one tree and a 1 (one) m long canopy gapon the transect line. SU 15 had no canopy gap on the transect line and as such connectivity was good although tree height varied.

The tree profile in SU 16 at Site 4 showed variation in height. The transect line was fully covered by canopy with good connectivity and no gap was present. Tree crowns were mostly good except for two trees on the transect line. There was a canopy gap of 4 m long on the transect line in SU 17 but connectivity at some parts of the transect was good. SU 18 had a good tree profile and varied in height. There was no canopy gaps on the transect line, which resuted in good connectivity. Good profile of trees was also observed in SU 19. Its canopy connectivity was good although only two trees were on the transect line with canopy gap of 1 (one) m long. Connectivity was also good in SU 20 with two trees on the transect line. However crown health of these trees was poor. Despite a number of instances of good connectivity detected in some parts of the habitat, overall assessment showed that the connectivity was poor. This depends on the ongoing process of illegal timber extraction that removes some of the larger trees which are also the preferred food plants for the monkeys. Removal of these food plants would affect the long-term survival of the monkeys.

Proboscis Monkey and other species occurrence

There was not much wildlife sighted in the study sites as shown in Table 4.17. Proboscis Monkey was very hard to sight at the study sites however local people who collected forest produce always encountered this monkey in the early morning (per. comm. with village folks). However, Long-tailed Macaque was very easy to sight according to local people. In this study, the movement of tree branches was detected once during travel by boat to the upper river, indicating animals jumping from tree branches but whether it was a Proboscis Monkey could not be confirmed.

Table 4.17: Species of wildlife sightings at swamp forest

Wildlife	Site	Literature	This study	Local people
Proboscis Monkey	Maludam	March 2002		June 2013
Long-tailed Macaque	NP			June 2013

Discussion

The swamp forest is another forest ecosystem which is ecologically different from the low closed heath forest, the medium closed heath forest and the flooded forest, although they have some similar species of plants. The forest ecosystems both inside and outside the park had deteriorated. Fragmentation and subdivision of landscape were more evident outside the park due to land clearing, resulting in very poor ecosystem. The impacts of this unsustainable land-use practice may explain the low primate density in this region (Bennett, 1992; Sabki & Tisen, 1998).

This habitat is facing exogenous threatening processes (Arroyo-Rodríguez & Dias, 2010). Illegal hunting activity along Btg. Lupar (pers. comm. with local people), although irregular, may also explain the low density of primates including Proboscis Monkey (Hon & Gumal, 2004). As the area outside the study site is dominated by humans and easy access to the habitat is already established, disturbance from human activities and intrusion continues. The illegal cutting of timber is an ongoing threat and its occurrence varies, possibly due partly to socio-economic pressure in relation to unemployment or local market demand. A large amount of residual cut sawn timbers were observed on the ground, and the sound of chainsaws could be heard whilst the surveys were being carried out. As a result of this, wildlife (especially Proboscis Monkey) was very hard to observe which resulted in a deterioration of the tourism value. Unlike in Lacandona rainforest, Mexico, where Howler Monkeys (*Alouatta pigra*) seem to be resistant to initial phases of disturbance in isolated forest (Arroyo-Rodríguez, González-Perez, Garmendia, Solà, & Estrada, 2013), Proboscis Monkey may not be tolerant of such disturbance. As such there is an urgent need to incorporate both prevention and mitigation strategies against this threatening process into the park management.

The density of food plants, especially *Syzygium* sp., was higher compared to those in the low closed heath, the medium closed heath, and the flooded forest, suggesting the recruitment process was high. This was evident in a number of the sampling units located at the upper river sites, where quantities of seedlings were present on the forest floor. Additionally, a few larger D.B.H. class of trees were enumerated in this habitat compared to the low closed heath forests, the medium closed heath forests and the flooded forests, although some of the trees were shorter than those in the medium closed heath forests. Licensed logging carried out in the past had resulted in many larger and emergent trees being harvested, leaving higher numbers of smaller trees. The stands formed uneven canopy layers which were common characteristics of stands in the post-logging forests. Some canopy gaps were larger compared to those in the medium closed heath forest and the flooded forest, and as such connectivity was poor. These canopy gaps would take a lengthy amount of time to recover, especially in the large cut lines created by heavy machinery. This habitat was highly utilized by Proboscis Monkey compared to other locations in Sarawak (Salter et al., 1985) however arboreal connectivity was not well established in some parts of the area.

The impact of disturbance diminished the quality of resources which in turn affected the monkey's foraging behaviour. Moreover, some vegetation along the river had been burnt, especially *Pandanus* species. *Pandanus* species is one of the preferred food plants of Proboscis Monkey and burning of this species will reduce their food stocks. According to local people, this activity was done during the dry season and at low tide with unspecified purposes. However, the availability of resources in this study site may explain the viability of the monkey populations (Chauhan & Pirta, 2010; McCarthy et al., 2009). Resource availability, habitat characteristics (especially forest structure) and connectivity are the enabling factors for habitat quality (da Silva Junior et al., 2009; da Silva Junior et al., 2010; Marshall, 2010). Although this habitat is divided by the river, Proboscis Monkey may not need to swim across the river because there were some locations where both sides of the river banks were connected with tree canopy. Some of the canopy gaps were manageable for the monkeys to traverse across the river from one crown to another. Therefore, not only good canopy connectivity but also vertical distance among the upper, middle and lower canopy in relation to forest strata can facilitate arboreal movement. The vertical gaps between the forest stratums in this habitat were too large and may not provide easy vertical movement. However, there were a number of canopy-trunk connections which also formed arboreal routes.

The density of undergrowth beneath a number of large trees was low partly due to suppression. These areas were mostly colonized by small woody plants, shrubs, palms, and rattan. However, some parts of the study sites where the density of the undergrowth was high may play an important role in forming corridors to bridge arboreal locomotion from one patch to another. However locomotion in the canopy tends to be difficult due to the absence of trees with high canopies (Fimbel, 1994). Horizontal locomotion on the ground would therefore be much further depending on extended gaps between individual stands. The presence of liana may help to secure arboreal movement, in particular when vertical movement such as ascending trunks might be difficult. The value of liana in assisting arboreal movement was also demonstrated in Bako National Park, where on a number of occasions Proboscis Monkey had to hang and walk on the insulated electric cable at the park headquarters in their daily activity, due to the absence of natural supports to cross over the cut lines of walking path.

During high tide some parts of the study site were flooded. The inundation of habitat may not adversely affect the monkeys because arboreal routes were the most preferred foraging route in relation to their foraging behaviour. As foraging behaviour mostly occurs in the canopy, arboreal movement beyond the boundary of this study site may not possible due to the presence of large forest gaps. Given this, the monkeys may be more vulnerable to disturbance during food scarcity in the park if they need to travel to the neighboring patches beyond the park boundary. Neighbouring patches are very important habitat to primates if they provide supplementary resources to meet their dietary requirements during food scarcity (Arroyo-Rodríguez & Dias, 2010). However, the deteriorated quality of neighboring habitats beyond the boundary of this park may not a reliable resource for the long-term persistence of the monkeys. A study using GIS radio-collar on Proboscis Monkey is needed to investigate the movement patterns of the monkeys inside and outside the park.

Overall, the habitat for Proboscis Monkey in the study area is subject to potential threats from anthropogenic activities or natural disaster either intrinsic or extrinsic. Any form of disturbance that occurs in the ecosystem will eventually change the forest structure and habitat characteristics.

4.4 CONCLUSIONS

Proboscis Monkey's habitats is regionally and nationally an important heritage as the monkey is endemic to Borneo and also one of the popular flagships for the Malaysian State of Sarawak. Thus, the protection of the monkey's habitats must be viewed in the wider context of long-term environmental conservation commitments. By virtue of this basic principle, threatening processes have been identified based solely on the study reported in the preceding sections of this chapter. More specifically these processes include, amongst others: illegal cutting of timber, burning, pollution and habitat removal. Therefore, the conclusions were made based on the objectives of this part of the study which were guided by the habitat quality indicators.

There were substantial differences in the status of Proboscis Monkey's habitats inside and outside of the protected areas. The forest structure outside the three national parks has been changed due to land clearing, leading to habitat fragmentation and isolation. The canopy connectivity was poor, especially in forests outside Maludam National Park. There were no more emergent trees outside the national park because natural forest had been replaced by agricultural plantations, man-made forest and human settlements. The forest structure and composition inside Maludam National Park and Kuching Wetland National Park also showed some changes due to past logging. These changes were evident in the reduction inboth overall size of trees and their connectivity. In contrast, no illegal logging had occurred in Bako National Park and there was limited evidence of changes in forest composition.

The forest structure and composition varied in all study sites. Bako High School mangrove was extremely isolated. Selabat riverine mangrove was only a small patch with very little numbers of small stands due to past removal of larger trees. Agricultural activity (especially aquaculture) was taking place in some parts of this habitat. The Selabat coastal mangrove had a number of good stands but its connectivity was slightly poor. Bako National Park had some smaller stands that grow in shallow soil conditions with poor nutrient content and a few larger stands with good canopy health. In contrast, Maludam National Park and Kuching Wetland National Park had no more emergent trees although they had a number of trees with larger D.B.H. class. They were dominated by some shorter trees with smaller D.B.H. class.

The study sites had food plants preferred by Proboscis Monkey. These food plants varied in terms of D.B.H. class distribution. All the study sites were dominated by trees with D.B.H. class 10-14 cm, however the heath forests in Bako National Park had much better D.B.H. class distribution compared to other study sites, as it was composed of various different types of D.B.H. class of trees. The representation of canopy height was also good in Bako National Park as it had a few dominant trees with open and far reaching branches. A number of these trees were 25 m high.

These forest characteristics not only provided proper sleeping sites but also served as safe arboreal routes for the monkeys.

All the study sites had threatening processes that affected their habitat quality which were not conducive to the monkeys' survival except the medium closed heath forests. The low closed heath forests are not suitable for the monkeys' survival because this habitat is isolated and contains low quality of forests. Bako High School mangrove has lost its diversity and has no connectivity outside the study site. The Selabat riverine mangrove was only composed of smaller and shorter trees and its connectivity was slightly poor. The Selabat coastal mangrove was also composed of shorter trees and this habitat was always inundated and under pressure from the strong tidal movements. Both of these habitats had human disturbance such as illegal harvesting of mangrove stands. In contrast, the riverine mangrove between Sg. Jebong and Sg. Pergam and other secondary sites in Kuching Wetland National Park were suitable for the monkeys, with the exception of mangrove at Pulau Salak. The mangrove habitat at Pulau Salak was isolated and under pressure by human disturbance especially the quarry activity. It was dominated by smaller and shorter mangrove stands. The flooded forests and the swamp forests were also not suitable for the long-term survival of the monkeys. Although they had some food plants and a number of trees which could provide sleeping sites, these habitats were threatened by an ongoing illegal extraction of timber. There was a continual process of replacement or recruitment in the overall areas but it was very slow. The intentionally burning of the plant species in Maludam National Park may exacerbate deterioration of the habitat quality.

Human disturbance is more threatening than natural disturbance. The potential impacts of human disturbance need to be properly managed to protect the ecosystem. While the future of habitat quality is unpredictable, park management should consider a holistic approach to overcome all the threats including interdisciplinary management for ecosystems both outside and inside the park, because habitat characteristics (especially forest structure) play an important role in determining the quality of habitat for this primate.

CHAPTER 5 BEHAVIOURAL ECOLOGY AND RELATED BEHAVIOUR

5.1 INTRODUCTION

Behavioural ecology of primates continues to attract much emphasis in primate research because almost half of the 634 primate species in the world are classified as threatened or endangered on the IUCN Red List (Caro & Sherman, 2011; Mittermeier et al., 2009). Most primates live in a cohesive group which becomes an important social element for effective response to any change in their habitat (Bates & Byrne, 2009). Primates interact differently to various types of habitat, light density variations between day and night (Curtis & Rasmussen, 2006), and spatial and temporal distribution of food plant species (Marshall et al., 2009). Primates not only show patterned forms of behaviour in response to their physical (food resources and sleeping sites) and their social environment (Kummer, 2006), but their behavioural activity patterns are also different according to habitat characteristics (da Silva Junior et al., 2010).

In a seasonal environment, some primates show predictable responses to fluctuating resources and switch to alternate, poorer quality food sources, increase the amount of time they spend foraging, or increase their daily path length when resources are decreasing (Gursky, 2000). In different types of habitat such as the Comoe' National Park, northern Ivory Coast, Africa, two habituated Olive Baboons

(*Papio anubis*) groups differ in feeding, foraging, moving, resting, drinking and socializing (Kunz & Linsenmair, 2008), suggesting a behavioural response to habitat variation. Some primates also show different behavioural patterns partly due to different demographic condition (Chapman & Rothman, 2009). While affiliated bonds between individuals in the group need to be maintained through social interactions (Lehmann, Korstjens, & Dunbar, 2007), ecological factors influence behavioural adaptations and number of individuals in the group (Chapman & Rothman, 2009).

Primates mostly maintain their daily foraging path through dense canopy, which allows them to avoid predation (Curtis & Rasmussen, 2006). In many cases they do not forage continuously as they move through the canopy but feed only in certain trees, often travelling directly from one source to another (Snaith & Chapman, 2007). As most primates live in cohesive groups, they forage in groups. Living in a group is also part of the strategy to increase fitness by avoiding predation (e.g. benefiting from group defence), or social pressures (e.g. infanticide) (Chapman, Rothman, & Hodder, 2009). Within the primate group, differences exist in movement between individuals also. For example, in Chimpanzee (*Pan troglodytes*) groups in Uganda, movement strategy differs not only among individuals but also among age categories, and in particular females, which is related to feeding requirements (Bates & Byrne, 2009). Male and female primates adapt their activity budgets in different ways to integrate modified resources into their broader ecological strategy (Hockings, Anderson, & Matsuzawa, 2012).

Primate behavioural patterns are not just a result of changes in foraging and patterns of individual behaviour, but also interconnections with humans and ecological constraints (Fuentes & Hockings, 2010). Likewise, adapted behaviour of primates to habitat change is reflected in their daily activity budgets including feeding, resting, and travelling. This has been demonstrated in many studies on activity budgets of primates. For example, Purple-faced Leaf Monkeys (*Trachypithecus vetulus nestor*) in Sri Lanka, show resting is their main activity in forest fragments and human-modified environments (Moore, 2008). Furthermore, primates can modify their feeding strategies inresponse to food availability, exploiting different foods with different nutritional and distributional characteristics at different times (Snaith & Chapman, 2007). In Sulawesi Island, insectivorous primates (*Tarsius spectrum*) modify their activity budgets in response to seasonal resources and they not only modify their foraging behaviour and spend more time travelling and foraging during wet season, but increase the amount of time foraging during times of low resource abundance (Gursky, 2000).

As for Proboscis Monkey, its activity budgets have showed variation in percentage of time spent feeding, resting and travelling in relation to different category of height of trees in two study sites (Sukau and Abai) in Sabah (Boonratana, 2000).

In the Menanggul River, Sabah, fluctuations in dietary diversity accessible to Proboscis Monkey are influenced by seasonal availability of fruit, but they engage more in resting as opposed to feeding and moving when availability of fruit is scarce (Matsuda et al., 2009a). Although fruit production affects the activity budgets of Proboscis Monkey (Matsuda, 2008), information on the effect of seasonal change on the activity budgets is still lacking. Thus, the preferred objective and sub-objectives of the research reported in this chapter are:

1. To investigate whether there is any difference in behavioural activities of Proboscis Monkey according to habitat characteristics.

1.1 To examine whether behavioural activities of Proboscis Monkey differ in relation to forest strata and crown levels.

1.2 To investigate whether behavioural activities of Proboscis Monkey differ among the age and gender categories.

1.3 To investigate whether there is any variation in monthly behavioural activities of Proboscis Monkey.

1.4 To examine whether wet and dry seasons influence behavioural activities of Proboscis Monkey.

5.2 METHODS

This section outlines in detail the methods of field data collection. It describes the technique for selecting the focal study groups of Proboscis Monkey (Boonratana, 2000; Matsuda et al., 2009b; Yeager, 1991b) and observing their behaviour. Each life stage of the focal group is defined and supported by the relevant literatures. The technique of recording the monkeys' defined behaviour may have some possible limitations because it was done within the five-minute intervals although continuous observation was made outside these observation intervals. This section also describes habitat use classification according forest types, forest strata and crown levels categories in relation to the observed focal group's position in the trees.

5.2.1 Research Time Schedule

Preliminary field surveys were undertaken over a three-month period in November and December 2010, and May 2011. The purpose of these surveys was to familiarize myself with the Proboscis Monkey groups, their behaviour and habitat, and identify relevant behavioural, life stage, and habitat categories. From this preliminary survey I designed and finalised field forms for recording behaviour in the field in a systematic and efficient way during the main survey (Appendix 12).

The main field survey was undertaken over a thirteen-month period from May 2011 to May 2012 at Bako National Park, and a twelve-month period from June 2011 to May 2012 at Kuching Wetland National Park, Sarawak, East Malaysia (Borneo). This twelve to thirteen-month study period ensured that daily and monthly variation and seasonal changes under the broad categories of wet and dry seasons could be accounted for over a period of at least one year. While the seasonal sampling is limited to just one year it does nevertheless provide baseline data through a preliminary assessment of seasonal variation. Long-term extrapolation from both the monthly and seasonal data is understood to be limited but given the comprehensive, detailed and rigorous nature of the field assessment (continuous behavioural observations) an important insight into Proboscis Monkey behaviour at these two very different field sites is provided.

In these two study sites the wet season, which averages 562 mm of rain, occurs from November to February, and the dry season, which averages 157 mm of rain, occurs from May to August. There were months outside the designated wet and dry season periods which were excluded from the analysis of seasonal change and these were September to October and March to April. From May and June 2011 to May 2012, a range of field data was recorded five days each week from Monday to Friday across the two field sites (Bako National Park and Kuching Wetland National Park) by myself, the principal investigator, and two field assistants (Field Assistant #1 and #2). I trained these two field assistants in data collection techniques and continuously supervised them as we worked at the same time and place. This was to establish the reliability of the data collection to ensure the application of a standardised process and inter-observer reliability. However, most of the data collection I did myself whilst the field assistants assisted with the phenological survey (phenological survey as described in Chapter 6). The total accumulated field time of 25 months, 310 days, and 2439 hours of direct observation ensured a comprehensive data set was available for analysis (Table 5.1).

Table 5.1: Field time at the two national park study sites

Park	# Months	# Days	# Hours
Bako National Park	13	158	1245
Kuching Wetland National Park	12	152	1194
TOTAL	25	310	2439

5.2.2 Study Individuals and Groups

The preliminary survey in May 2011 was also undertaken to observe and identify the Proboscis Monkey troop to be followed, its size and composition. For the purpose of this study I selected a one-male group (a group with one male) from each study site and I followed this focal group with one field assistant from June 2011 to May 2012. The use of a focal group for data collection of animal behaviour is well established in primate research as it is considered an efficient, reliable and representative sampling unit (e.g., Boonratana (2000); Chapman et al, (2007); Chapman et al, (2000); Matsuda et al, (2009b); Milton (1980); Yeager (1991b)). A one-male group which consists of an adult alpha male, females, offspring, and young males, is the basic social unit of Proboscis Monkey (Bennett & Sebastian, 1988; Yeager, 1990), and so the most representative of mixed membership. This allows for behavioural activity according to age and sex categories of the group members to be recorded and possible variations to be determined.

In Bako National Park, I identified three groups of Proboscis Monkey, each with their respective young off-spring. The difference between these three groups was that they had 18, 15 and 5 individuals respectively, including offspring. I selected the group of 15 which was habituated and easy to identify, as one of its females was having a problem of fur loss and her skin looked very exposed. This observed group was relatively stable. They only joined together with other groups in the mangrove forest over the study period. Observations were undertaken on foot.

In Kuching Wetland National Park, I identified two groups of Proboscis Monkey which comprised of 18 and 22 individuals respectively. I selected the group of 18 which was found to have one baby with dark brown fur on its body. The group size had always been monitored. There were two sub-adult females immigrated and a juvenile with a sub-adult female emigrated throughout the study period. But the number of individual within the observed group remained the same at the end of the study period. The survey was carried out using a small boat mounted by a 15 horse power engine and on foot during high and low tide in the area between Sg. Pergam and Sg. Jebong area. The movement of boat was maintained between 10 and 15 km per hour. The boat engine was switched off and padaled to the closest possible distance to the observed group or individual when they were sighted to record their behavioural activities (Sha et al., 2008).

The observations were both incidental and systematically recorded allowing for a combination of qualitative and quantitative analytic procedures to be applied. Observation of the two selected focal groups was done continuously during the day for three to four days a week. The remaining days in each week were allocated for phenological work, mapping the feeding and sleeping places, and identifying the food plants in both study sites (Milton, 1980). My field assistant and I followed each age and gender category of focal monkey on different days from the selected one-male group. The life stage categories of these focal monkeys were adult male, adult female, sub-adult male, sub-adult female, juvenile (Bennett & Sebastian, 1988), pregnant and lactating female. I used the categories as described by Bennett and Sebastian (1988) to identify the focal monkeys but included additional information such as size, weight and age range for each category (Table 5.2).

Table 5.2: Life stage categories of Proboscis Monkey

Life Stage Category	Size Range (centimetres)	Weight Range (kilograms)	Age Range (years)	Physical Characteristics
Adult male	73-76	15.10 - 25.20	7 – 25	full body size with huge, pendulous and fully developed nose, dark brown mane of hair across back, has a darker cap over the top of his head, a strikingly white rump patch of much shorter fur, leading to a long, thick white tail
Adult female	61-64	7.00 – 12.50	5 –	full adult body size with smaller nose , droop somewhat but not pendulous compared to male, no striking contrast of colour, rump patch and tail is somewhat darker, and tail not as thick, elongated nipples.
Sub-adult male	62 - 65	7.00 – 15.00	5 – 7	more than ¾ full body size or full body size but without fully developed nose and/or mane of hair across back
Sub-adult female	59 - 62	5.00 – 6.70	3 – 5	more than ¾ but not yet full adult body size with fairly short-snub nose, nipples non-elongated.
Juvenile	35 –	2.55 - 3.50	1 - 3	animal with adult-coloured face and brown fur coat but not yet ¾ full adult size. N.B: Juvenile males can be the same size or larger than adult female,
Infant - 2	– 35	1.35 – 1.50	4-12 months	animal with brown fur on head and body but with at least some dark skin on face.
Infant - 1			new-born - 4 months	animal with dark brown/black fur on body and/or head with dark-coloured face.

(Sources: Allen & Coolidge (1940); Beavitt & Tuen (2010); Bennett & Gombek (1993); Bennett & Sebastian (1988); Bismark (2010); Bismark et al. (2000); Boonratana (1993); Kern (1964); Matsuda et al. (2008); Rajanathan and Bennett (1990); Rowe (1996); Schultz (1942); Yeager (1990))

The life stage composition of the two study focal groups were as outlined in Table 5.3

Table 5.3: Life stage composition of focal groups

Life Stage Category	Bako National Park Focal Group	Kuching Wetland Focal Group
Adult male	1	1
Adult female a) Lactating b) Non lactating	 2 3	 2 5
Sub-adult male	2	2
Sub-adult female	2	3
Juvenile	3	3
Infant – 2	1	1
Infant – 1	1	1
Total	15	18

5.2.3 Behavioural Observations

Fourmain behaviours were identified and recorded during the periods of direct observation of the focal group and/or individual. These behaviours were defined as follows and are in accordance with other research undertaken in the field (Matsuda, 2008; Milton, 1980; Salter et al., 1985; Soendjoto, 2005; Soerianegara et al., 1994).

a. Feeding

   Feeding is eating and/or drinking something. This also includes the feeding process: plucking or putting something into mouth, chewing and swallowing.

b. Resting

   The monkey is considered resting when it is predominantly in an inactive state but includes defecating, and urinating. Physically there is no feeding and moving from tree to tree, or climbing, or shifting from one sitting place to another sitting place on the same branch of tree, or on the forest floor.

c. Travelling

Travelling is spatial change in monkey's position including moving from tree to tree, or climbing, or shifting from one sitting place to another sitting place on the same branch of tree, or on the forest floor. This behaviour also includes moving while chewing something in mouth.

d. Other

Any behaviours that are not falling within the above three defined behaviours, including grooming, copulation, swinging, and social interactions.

These feeding and other related behaviours were systematically sampled (Altmann, 1974) and recorded in five-minute intervals every 30 minutes from 6:30 am to 6:30 pm at each study site. This provided a quantitative data set of number of behavioural events per five-minute-sample period across the twelve-hour period, totalling 22 five-minute-sample periods per day of follow and direct observations. In addition to this events sampling method, the group was continuously observed outside the five-minute intervals such that it was not lost from sight. Outside the five-minute-sample period incidental observations were recorded in a field note book. My field assistant and I chose another focal monkey when the first observed one was lost for more than 30 minutes. The use of a focal animal sampling method within the focus group (Altmann, 1974) was applied for recording behavioural data. The repeated sampling of particularly conspicuous individuals (Chapman et al., 2002) was avoided by purposely recording data on a focal animal from each age and sex category on different days. The data collected is therefore representative of the mixed membership of the focus groups. However, the lactating female was always lost from sight in Kuching Wetland National Park such that the analysis was not made for this age and gender category due to insufficient data.

Our daily routine was to arrive at the sleeping place at 6:00 am, which was identified at 6:30 pm or 7:00 pm on the previous census day. I recorded the daily feeding and sleeping locations using Garmin GPSmap 76CSx. The focal group was continuously followed for the whole day till 7:00 pm or until the monkeys set up the next sleeping place. This sequence was followed until the end of both the twelve and thirteen-month survey periods.

5.2.4 Landscape and Habitat Use Classification

As the daily routine work progressed, I realized that the focal groups in both study sites had appeared to demonstrate a pattern in terms of habitat use as part of their ranging behaviour. This pattern of use was formalised into a spatial configuration across the study sites and some aspects of the behavioural data was collated and analysed according to that configuration.

Bako National Park I marked this pattern by dividing the study area in Bako National Park area into seven ranging habitats from Habitat 1 (H1) to Habitat 7 (H7) based on geographical features such as gullies, ridges, cliffs, and vegetation, etc (Figure 5.1) and located them by GPS as a control position. I ranked these according to food source availability and quality, vegetation composition and terrain characteristics; from 1=poor, 2=slightly poor, 3=fairly good, and 4=good (Table 5.4) in relation to habitat types described in Chapter 4.

H1-Habitat 1, H2-Habitat 2, H3-Habitat 3, H4-Habitat 4, H5-Habitat 5, H6-Habitat 6, H7-Habitat 7

Figure 5.1: Map of habitat use classification in Bako National Park

Table 5.4: Bako National Park habitat categories used by the study focal group

BNP Habitat Use Categories	Habitat Types (Chapter 4)	Location	Geographic Features or Terrain Characteristics	Food Sources or Vegetation	Ranking
H1	Medium closed heath forest	Area from the junction of Paku-Lintang Trail to 300 m distance at Paku Trail.	Interfaced with mangrove forests on the left and cliffs on the right.	Most of food plants are clumped, especially *Syzygium* spp., *Garcinia* spp. and other species from families of Myrtaceae, Clusiaceae, Anacardiaceae, Annonaceae, and Rubiaceae.	4 = good
H2	Medium closed heath forest	Immediately after H1 to 600 m along the Paku Trail.	Interfaced with coastal vegetation on the left and some high cliffs on the right with a few gullies.	Food plants fairly patchy in spacing, especially species from the families of Dipterocarpaceae, Sapotaceae, Pandanaceae, Myrtaceae and Lauraceae.	3 = fairly good
H3	Coastal mangrove	Interfaced with Teluk Assam river on the south part near the boat terminal.	Coastal and riverine	Dominated by a small pocket of mangrove, especially the families of Sonneratiaceae, and some Avicenniaceae and Rhizophoraceae. Some of the *Sonneratia alba* are dying	2 = slightly poor
H4	Medium & Low closed heath forests	Ascending to Lintang Trail from 50 m to 300 m along the trail.	Interfaced with a 15 m wide gully on the right and another small gully (5 m wide) on the left. From altitude 49 m to 84 m, rugged surface with rocks underlying soil.	Food plants fairly patchy in spacing, especially from the families of Dipterocarpaceae, Clusiaceae, Myristicaceae, and Tiliaceae.	3 = fairly good
H5	Medium &Low closed heath forests	Laying over two gullies on the north part of H2 and H4.	Northern part is interfaced with a 20 m wide valley and ravine. The eastern section is interfaced with H6.	Food species from the families of Dipterocarpacea and Anacardiaceae are found in patchy distribution. A number of trees with an open and outreaching branch system provide a good sleeping site for the monkeys.	3 = fairly good
H6	Low closed heath forest	Immediately after H4 to 600 m along Lintang Trai	Laying from 300 m to 600 m at the altitude 100 m. Interfaced with open shrubland or 'fire padang' on the east, 30 m deep ravine on the north and a gully on the south.	Some of the vegetation is less than 10 cm D.B.H. (diameter breast height).	2 = slightly poor
H7	Medium& Low closed heath forest	Interfaced with H3 on the south and H4 on the north.	High rise-cliffs with altitude more than 100 m and difficult to traverse over.	A number of food plants are found on the cliffs including species from family of Anacardiaceae. The Proboscis Monkey was rarely found in this habitat.	2 = slightly poor

Kuching Wetland National Park Habitat use patterns in Kuching Wetland National Park were divided into three behavioural polygons which were located using GPS as a control position (Figure 5.2). The spatial layout of these polygons was defined according to forest composition, forest floor characteristics, mangroves species and distance from river and named as follows - fundamental polygon (furthest from the main river), marginal polygon (in between fundamental and central polygon) and central polygon (border with main river). I ranked these according to food source availability and quality, vegetation composition and terrain or forest floor characteristics; from 1=poor, 2=slightly poor, 3=fairly good, and 4=good (Table 5.5) in relation to habitat types described in Chapter 4.

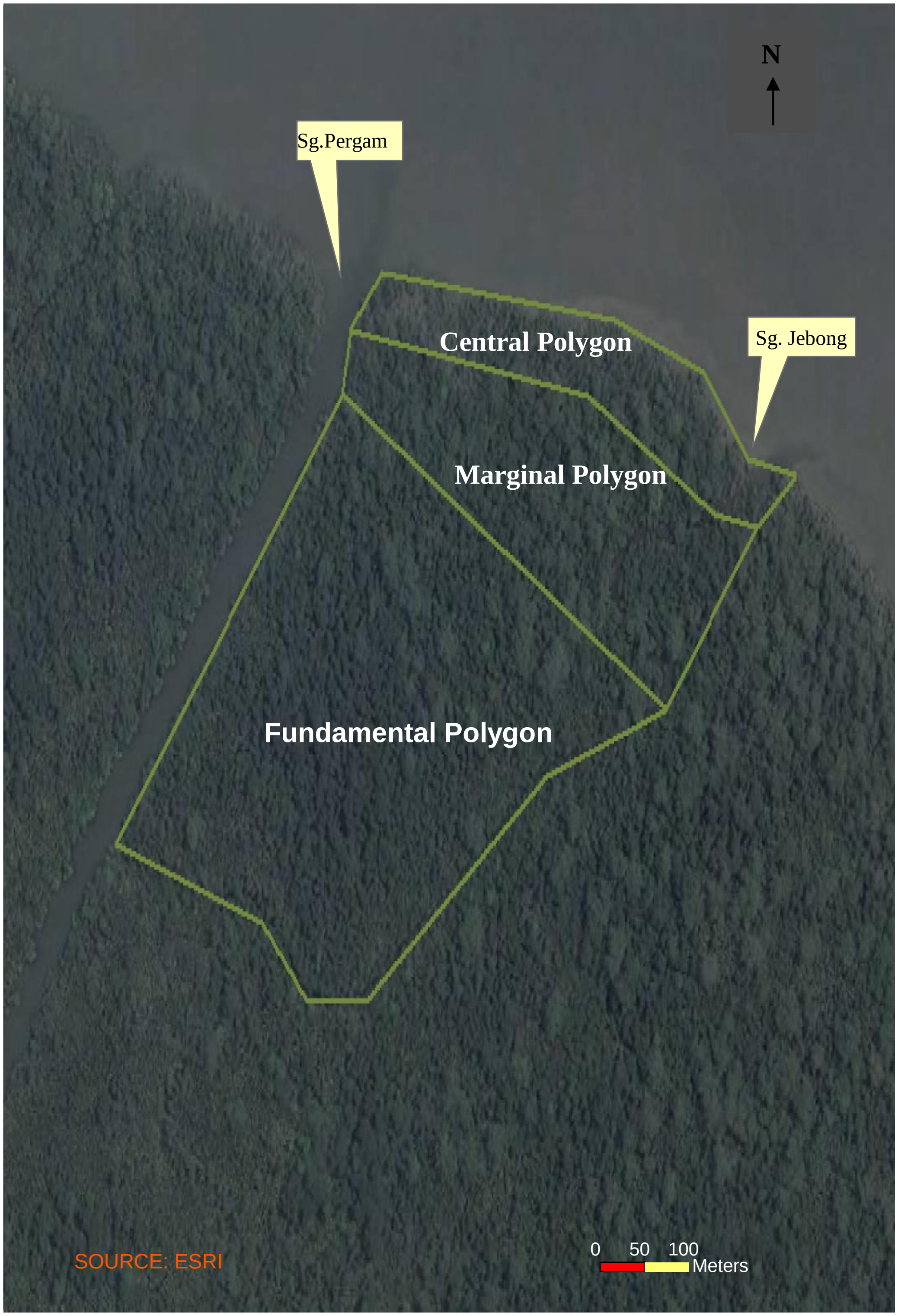


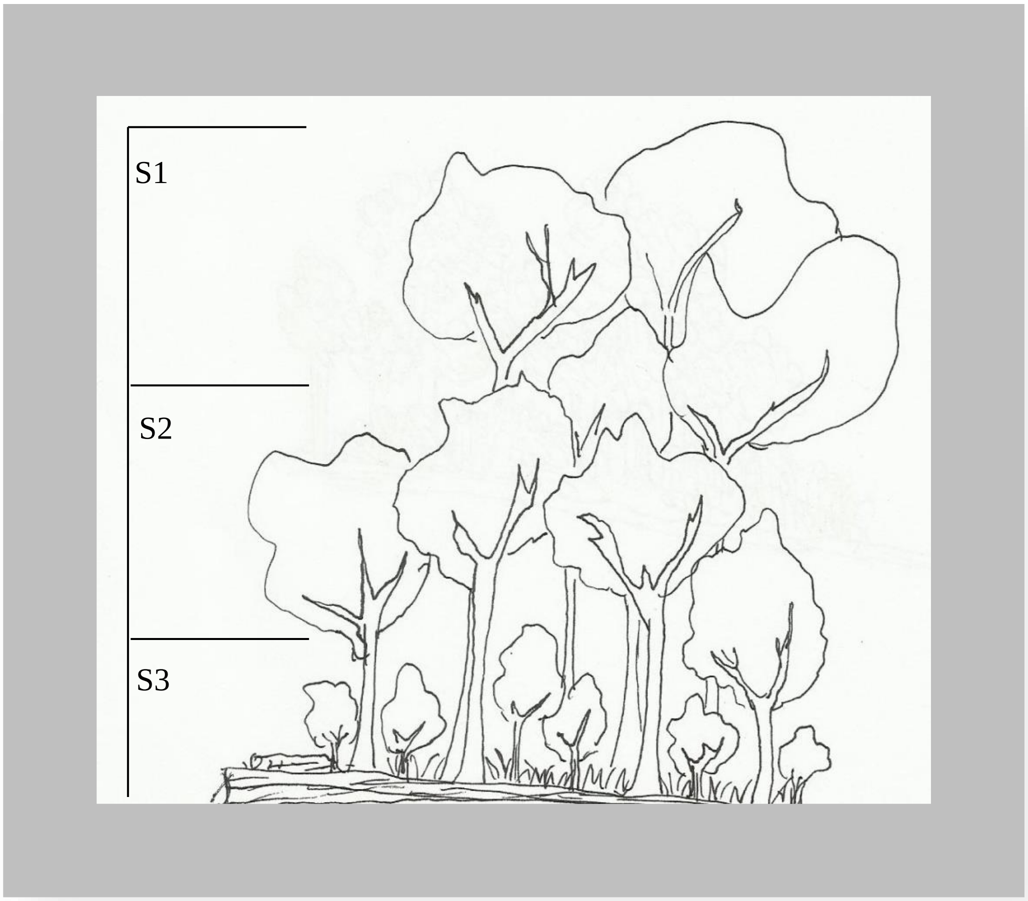
Figure 5.2: Behavioural polygons in the study site in Kuching Wetland National Park.

Table 5.5: Kuching Wetland National Park habitat categories used by the study focal group

KWNP Habitat Use Categories	Habitat Types (Chapter 4)	Location	Geographic Features or Terrain and Forest Floor Characteristics	Food Sources/Vegetation	Ranking
Central Polygon	Riverine mangrove	Border with the main river on the north and marginal polygon on the south	Whole area is inundated daily by the high tide. Muddy, sandy, wet and flat forest floor covered withpneumatophores.	Dominated by *Sonneratia-Avicennia* communities	4 = Good
Marginal Polygon	Riverine mangrove	In between fundamental and central polygons	Some parts of the forest floor are covered with pneumatophores, wet, muddy and inundated daily by the high tide. The drier parts are colonized by ferns.	Characterized by an *Avicennia-Rhizophora* community with a few *Nypafruticans*and ferns, and a number of *Xylocarpus* spp.	4 = Good
Fundamental Polygon	Riverine mangrove	Furthest from the main river (140 m). Border with a small stream on the south	Some parts of the forest floor are wet, muddy and inundated daily by the high tide. The drier parts are colonized by ferns and covered with forest litters.	Mostly dominated by *Nypafruticans*and ferns, and a number of *Xylocarpus* spp.	3 = Fairly good

5.2.5 Classification of Forest Strata and Crown Level Categories

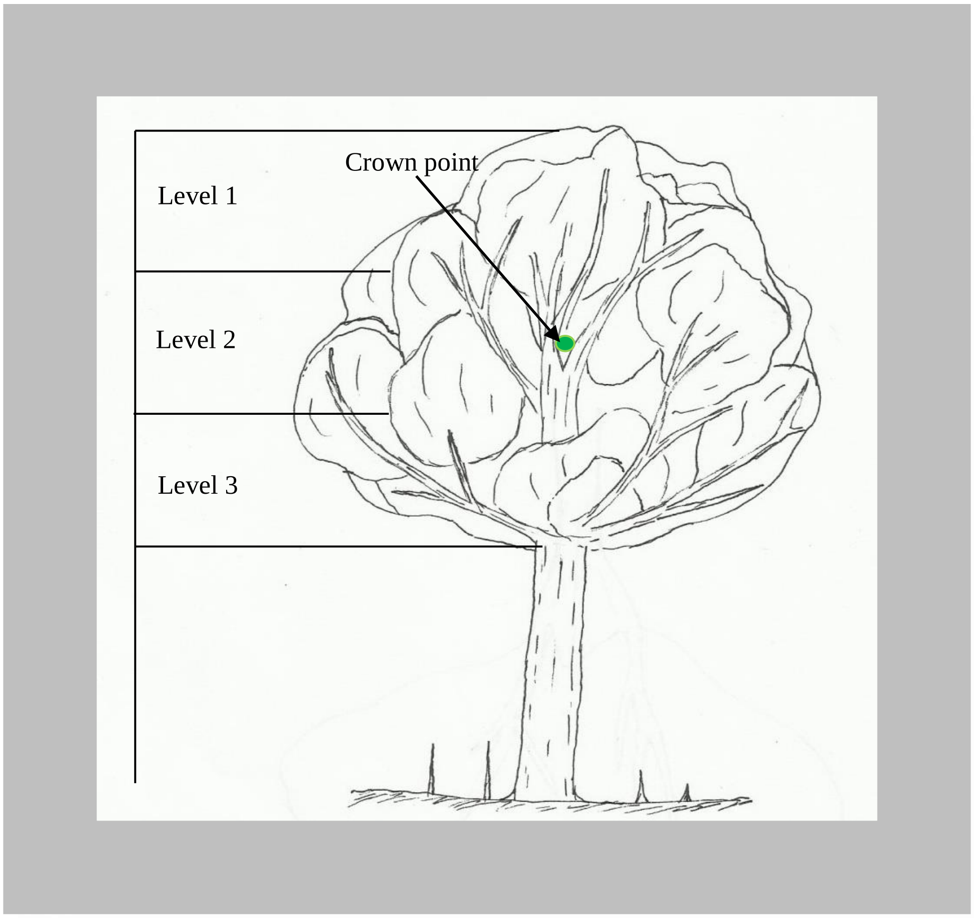
The behavioural activities of Proboscis Monkey occurred within different forest strata and individual tree and crown levels. I classified the different forest strata and crown levels (Figures 5.3 and 5.4.) to analyse data according to these categories. This classification follows standard forestry practices (Crookston & Stage, 1999; Sterck & Bongers, 2001; Ward & Stephens, 1993; Zarnoch, Bechtold, & Stolte, 2004).



S1 – 1st Stratum, S2 – 2nd Stratum, S3 – 3rd Stratum

Figure 5.3: Diagrammatic profile of forest strata

Because of the spatial separation of trees in the riverine mangrove forest of Kuching Wetland National Park, and the fact that one or two trees were most often occupied by the Proboscis Monkey, position within the tree as opposed to position within the forest structure was also classified. When tree activity took place, Proboscis Monkey's position could be classified into three categories of crown levels which I named as Level 1, Level 2 and Level 3. I divided the tree crown into three intrinsic sections which represent Top Level Crown, Middle Level Crown, and Bottom Level Crown respectively (Figure 5.4).



Level 1 – Top Level Crown, Level 2 – Middle Level Crown, Level 3 – Bottom Level Crown

Figure 5.4: Categories of crown levels

5.2.6 Data Analysis

Daily Routine I extracted only twelve hourly observations a day (from 6:30 am to 6:30 pm) of the age categories of this study group of Proboscis Monkey for analysis. The chi-square test of independence factors was used to test significant differences between activity performed by male and female Proboscis Monkey. The non-parametric Mann-Whitney *U*-test for two independent samples was also used. P-values of 0.05 or less were considered significant.

Monthly Routine *Data* from twelve-hour observations between 6:30 am and 6:30 pm, combined into monthly records, was used to analyse monthly routine behaviour. The chi-square test of independence factors was used to test for significant differences between activities and months. The non-parametric Mann-Whitney *U*-test for two independent samples was also used. P-values of 0.05 or less were considered significant.

Seasonal Variations I used data of twelve-hour observations to analyze defined activities between wet and dry seasons. The non-parametric Mann-Whitney *U*-test for two independent samples was used to test for significant differences between wet and dry season. The chi-square test of independence factors was also used. P-values of 0.05 or less were considered significant.

5.3 RESULTS

5.3.1 Behavioural Pattern

a. Bako National Park

Regular daily observations of the one-male focus group (harem) of 15 individuals in Bako National Park provided an important insight into behavioural activity patterns in general, and specifically the foraging activities of this study group of Proboscis Monkey.

Daily activity within this focus group commenced as early as 6:20 am and was instigated by the adult male of the group, which normally moved slowly from its sleeping position. Five minutes later this adult male often crawled to the nearest branch. This move was followed by other individuals in the group but was not synchronized. Generally, all members in the study group had completely moved from the tree where they slept by 6:30 am, moving to the next tree to start feeding. I often found Proboscis Monkey urinated after first waking and/or after having stopped feeding in the morning (between 6:45 am and 7:15 am) and in the afternoon (between 12:30 pm and 2:10 pm). This behaviour was sometimes followed by defecation.

Movement Pattern When travelling (especially leaping, walking or running) from one tree to another, normally a female Proboscis Monkey moved first, followed by others in the group. This movement from one tree to another formed an identifiable and structured rhythm. However, as a whole group this rhythm was often intercepted with staggered moves involving a lapse of time of a few seconds or minutes between moves of the individuals. Occasionally, the rhythm of the group movement was unstructured due to a disturbance which existed within and/or around the foraging range. This reflected the scattering and multi-directional nature of the movement of individuals in the group.

The daily path of the observed Proboscis Monkey in Bako National Park passed through both mangrove and heath forests and most often (96% of observations) followed an anti-clockwise direction. Of the fifty-four 12 hourly observations, forty-eight observations showed that they came to the coastal mangrove (H3). Of this forty-eight observation periods they were observed to use a clockwise directional path only 4 per cent of the time. This direction was identified when this study group came down to the mangrove forests from Habitat 1. In proceeding from there to the heath forest, the daily path they used was via Habitat 7 to return to Habitat 1 or Habitat 4.

Sleeping Sites and Positions After daily activities, the adult male Proboscis Monkey was found on several occasions to have slept either in the first or second stratum of the heath forest (see Figure 5.3). Adult females, juveniles (both genders) and lactating females always slept at the second stratum of the heath forest (see Figure 5.3). All members in the group often faced seawards when sleeping. Sleeping positions that were incidentally recorded were:

a. Sitting on open and outreaching branch
b. Sitting on branch base but leaning backward on tree stem
c. Lying front or ventral down on branch

Other Activities Other activities observed were grooming, playing and copulation. There were two incidents of copulation that involved an adult alpha male with two sub-adult females in the morning. Each copulation process lasted about 10 seconds.

b. Kuching Wetland National Park

As with Bako National Park the regular daily observations of the one-male focus group of 18 individuals in Kuching National Park provided an important insight into behavioural activity patterns in general and specifically the foraging activities (see Chapter 6) of this study group of Proboscis Monkey.

Daily activity of this study group was instigated by the adult male which started moving as early as 6:25 am. All individuals in this study group started foraging at 6:30 am. Their movement was staggered. They often urinated, sometimes followed by defecation, especially in the morning (6:30 - 8:00 am), seldom in the afternoon (12:00 – 1:00 pm) and very rare in late afternoon (4:30 – 6:30 pm) or in the evening. Occasionally, they were found eating the young leaves of mangrove tree where they slept, but most often they moved from the tree or trees where they slept to another tree for feeding.

Movement Patterns Similar to Bako National Park, a female Proboscis Monkey would initiate daily activity first by travelling from tree to tree. Their movements from tree crown to another were often observed by the adult male. They performed a very structured rhythm of movement, but their movements appeared much faster than the study group in Bako National Park. This may have been partly due to their response to our presence, as this group was less habituated to human presence. The movements of individuals within the group were staggered and the time lapse between moves of the individual was also briefer. Occasionally, the movement rhythm was unstructured compared to the study group in Bako National Park when disturbance existed within and/or around their foraging range. Apart from local fishermen's boats, the presence of tourist boats was the most frequent cause of disturbance to prompt movement of this study group of Proboscis Monkey.

The frequency of tourist boats (Figure 5.5) was on average 5 boats a day but only on 7 occasions did the presence of these boats interrupted my observations, and they were only half an hour in the vicinity of the monkeys under observations. As the work progressed the tourist boats did not come closer to the monkeys under observation indicating they knew that their actions would disturb my observations. The distance between myself (in the boat) and the study group above in a mangrove tree was between 3.7 m and 4.6 m. At this distance the group appeared tolerant to our presence and it was close enough for detailed and continuous observations to be made. If there was no disturbance, this study group could be observed for the whole day in the mangrove trees at the river edges. Daily activities of this observed group were mostly confined to within the small pocket of coastal mangrove between Sg. Pergam and Sg. Jebong.

Figure 5.5: Tourist boat in the study area

Sleeping Sites and Position This study group of Proboscis Monkey changed their sleeping sites every day. They most frequently slept in a large (averaged 10 m high) *Avicennia* sp. with outreaching and open branches which accounted for 40 per cent of the total observations. On a number of occasions this study group slept together in this one *Avicennia* tree. On other occasions the trees where they slept interchanged among the different species of mangrove trees including *Sonneratia* sp., *Rhizophora* sp. and *Xylocarpus* spp. Occasionally, they were found sleeping in more than one or two trees where there was no connectivity between tree crowns. They were found on several occasions to have slept either in Level 3 and Level 2 of the tree crown with the adult male always at the higher position. Most of their sleeping positions were:

a. Sitting on open and outreaching branch
b. Lying front or ventral down on branch

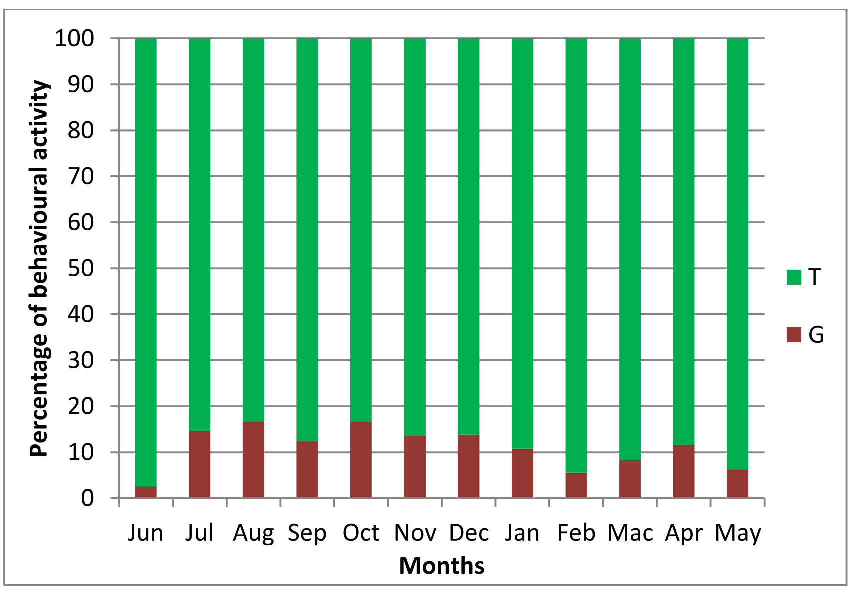
Other Activities Other activities observed were grooming, playing and napping. Copulation amongst this study group of Proboscis Monkey was not observed over the study period. During low tide they were observed on a number of occasions to walk from Sg. Jebong to Sg. Pergam or vice versa. Occasionally, they were found resting on the hard ground or the woody debris on the forest floor after ground foraging. Long resting periods normally took place in mangrove trees during either low or high tide, in the afternoon. Sometimes long resting periods were interchanged with other activities. These activities included grooming each other and playing. Juveniles played with one another, kicking and chasing each other. On a number of occasions this activity lasted for more than one minute.

5.3.2 Behavioural Routine

a. Bako National Park

Tree and Ground Activity In Bako National Park the study group of Proboscis Monkey utilised a number of trees of the same and varied species in their daily activity routine (identification of the species will be provided in the section on diet in Chapter 6). Over the whole period of field work, from June 2011 to May

2012, they were most frequently active within the confines of trees, rarely venturing down to the forest floor. This was mainly associated with the need to travel across open spaces at the interface of heath and mangrove forests due to a lack of canopy connectivity, rather than ground activity itself. Fifty-two systematic observations revealed that 89 per cent of behavioural events in heath forests were recorded in trees as opposed to on the ground (11%). Some monthly variation was evident with less than ten per cent of ground activity occurring in February, March, May and June (Figure 5.6). The longest frequency of ground activity occurred in August (dry season - 16.7%) and October (16.7%).

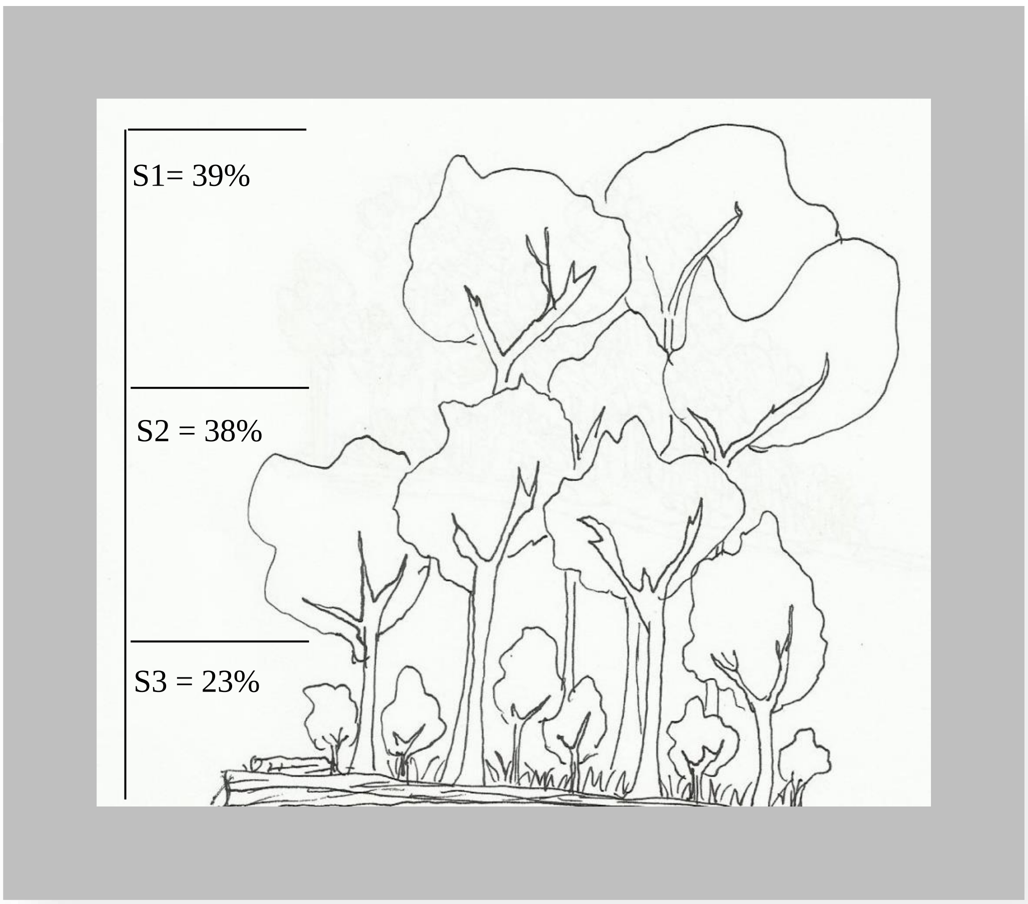


T – tree activity; G – ground activity

Figure 5.6: Monthly percentages of tree and ground activity in the heath forests

Behavioural activity in trees was further classified according to three forest stratums (Figure 5.7). Of this activity most occurred in the first (S1 - upper canopy

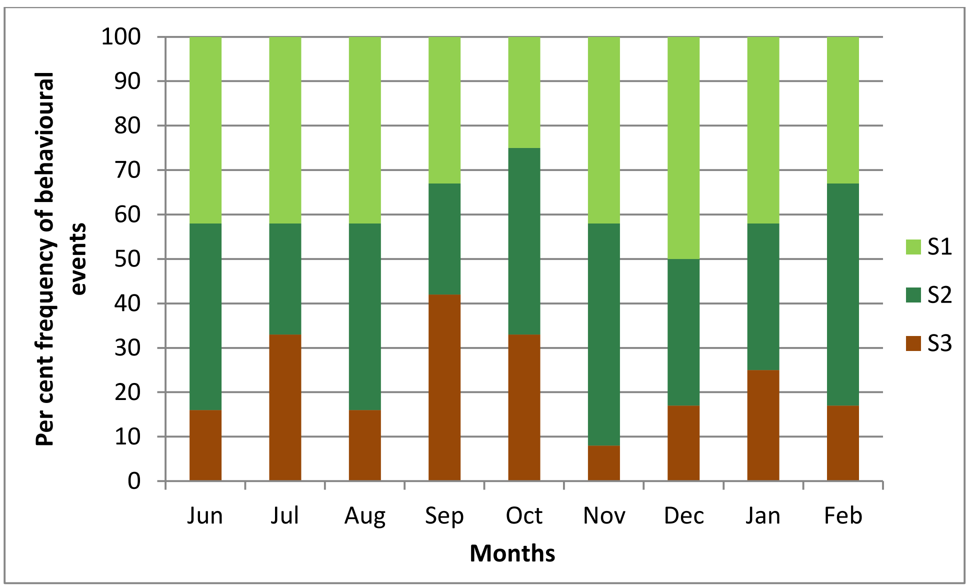
39%) and second (S2 - middle canopy 38%) stratum of heath forests, which accounted for 77 per cent of the behavioural events recorded (Figure 5.7). The remaining 23 per cent of activity occurred in the third stratum of forests or undergrowth or understory but above the ground (S3). This analysis was based on nine months of observation as data for other months was insufficient.



S1 – 1st Stratum, S2 – 2nd Stratum, S3 – 3rd Stratum

Figure 5.7: Percetage of behavioural activities at different forest stratums

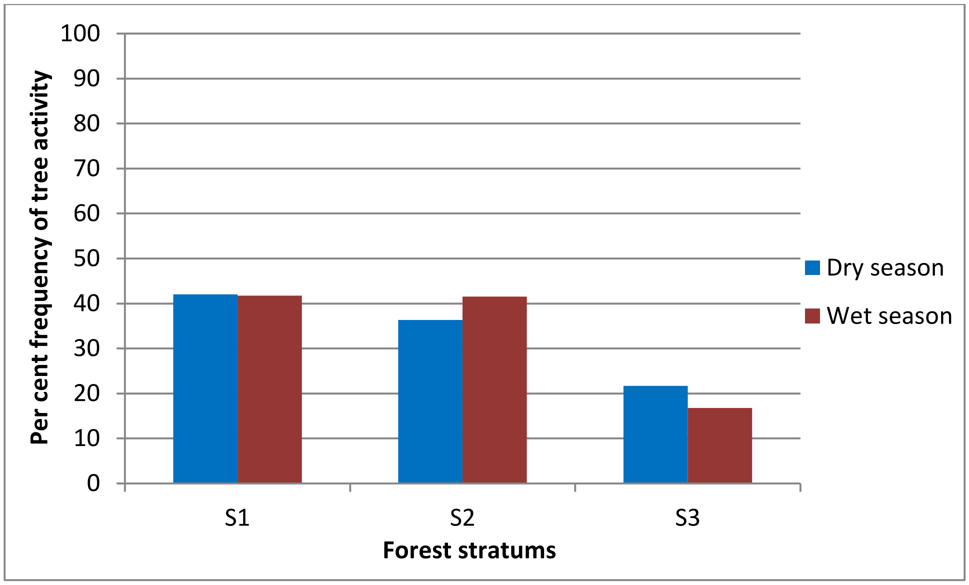
Monthly variation in the location of where activity occurred within the forest structure was evident (Figure 5.8). Most activity in the upper canopy (S1) occurred in December (50%), in the mid canopy (S2) in November (50%) and February (50%), and in the lower canopy or understory (S3) in September (42%). Conversely, behavioural activity occurred less frequently in the upper canopy in October (25%), in the middle canopy in July (25%) and September (25%), and in the lower canopy in November (8%).



S1 – 1st Stratum, S2 – 2nd Stratum, S3 – 3rd Stratum

Figure 5.8: Monthly per cent frequency of behavioural activities in different stratums of heath forests

While this study group mostly preferred upper canopy (S1) as opposed to other forest stratums, upper canopy activity (Figure 5.9) also occurred most frequently in both dry (42%) and wet (41.7%) seasons. However, the frequency of tree activity during the wet season in the upper canopy was almost similar to mid canopy (41.5%).

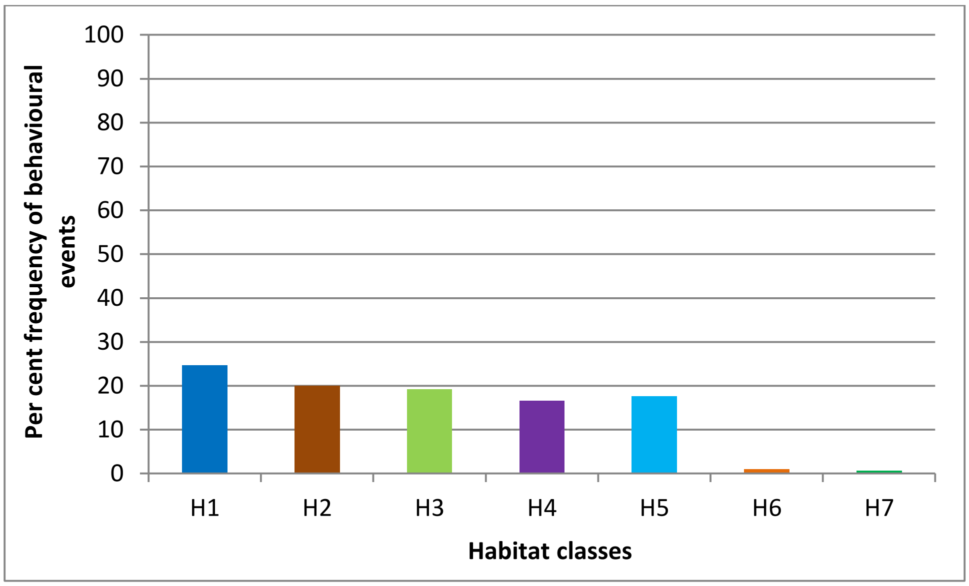


S1 – 1st Stratum, S2 – 2nd Stratum, S3 – 3rd Stratum

Figure 5.9: Percentage of tree activity according to seasons

Ground activity took place in both heath and mangrove forests. However, limited observation of behavioural events was possible during ground activity in heath forests. This was due to the forest floor in heath forests being covered with thickets and rugged rocks, and occasionally the study animals being hidden behind rocks or screened by palm frowns. Ground activity was most frequently performed by juveniles of this study group of Proboscis Monkey (60%), whereas other age categories were seldom found to engage in ground activity in heath forests. Conversely, ground activity in mangrove forests involved all age categories.

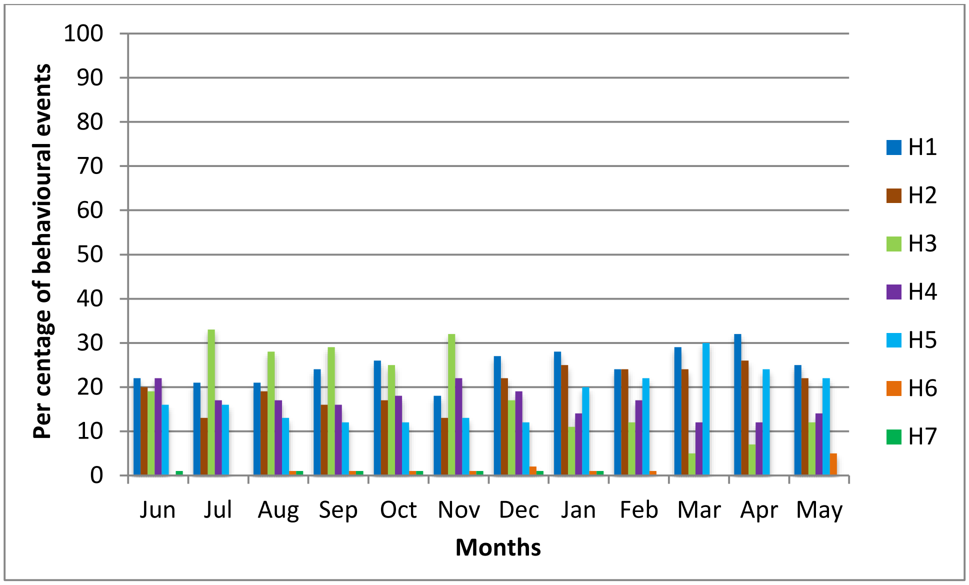
Habitat Preference According to the spatial configuration of the seven habitat categories identified for this study site (see section 5.2.3), a total of 53 twelve-hour observations (636 hours) showed that this study group of Proboscis Monkey was most active in H1 and H2 (medium closed heath forests), and H3 (coastal mangrove) which accounted for 25, 20, and 19 per cent respectively of their combined activities (Figure 5.10). They were least active in H6 and H7 (low and medium closed heath forest), areas with deep ravines and gullies (see Section 5.2.4)



H1-medium closed heath forest, H2-medium closed heath forest, H3-coastal mangrove, H4-medium & low closed heath forests, H5-medium & low closed heath forests, H6-low closed heath forest, H7-medium & low closed heath forests

Figure 5.10: Occurrence of behavioural activities in different habitats in Bako National Park

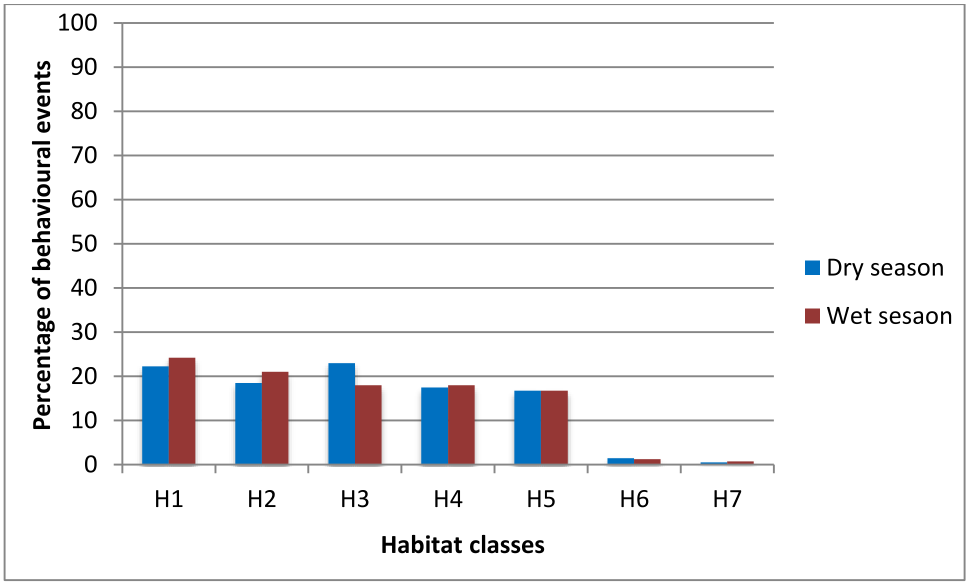
Figure 5.11 shows monthly variation in activity according to these habitat categories, with this study group most active in H3 (coastal mangrove) in July (33%), August (28%), September (29%) and November (32%). Compared to other habitats they were most active in H1 (medium closed heath forest) in October (26%), December (27%), January (28%), April (32%), and May (25%).



H1-medium closed heath forest, H2-medium closed heath forest, H3-coastal mangrove, H4-medium & low closed heath forests, H5-medium & low closed heath forests, H6-low closed heath forest, H7-medium & low closed heath forests

Figure 5.11: Monthly behavioural activities in different habitats in Bako National Park

Seasonal variation according to habitat category use was also evident with them engaging more frequently in behavioural activity in H1 (medium closed heath forest - 24%) during the wet season and in H3 (coastal mangrove - 23%) during the dry season (Figure 5.12).



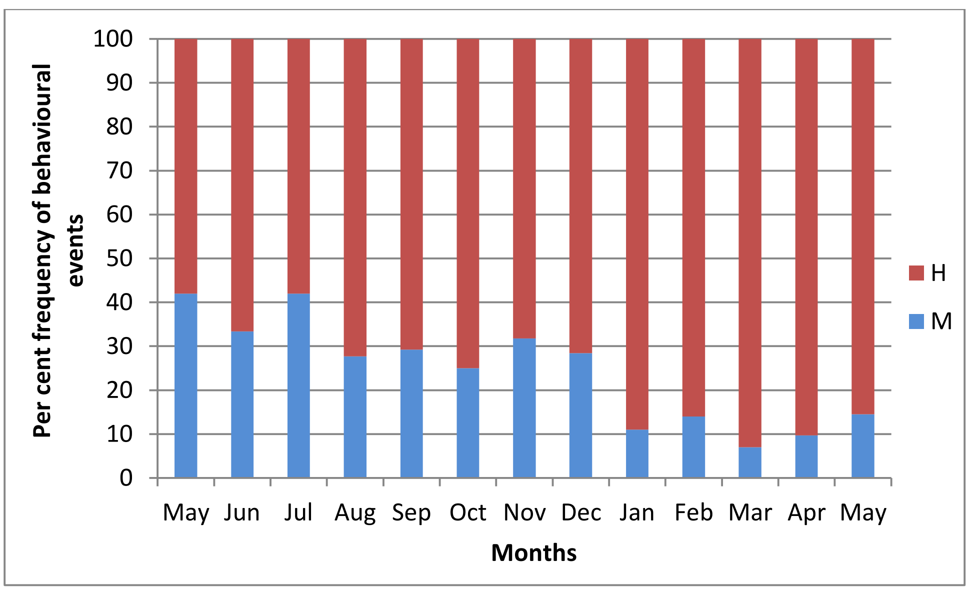
H1-medium closed heath forest, H2-medium closed heath forest, H3-coastal mangrove, H4-medium & low closed heath forests, H5-medium & low closed heath forests, H6-low closed heath forest, H7-medium & low closed heath forests

Figure 5.12: Percentage of behavioural activities in different habitats according to seasons in Bako National Park

Activity in Mangrove Forest

Behavioural activity of this study group of Proboscis Monkey in the mangrove forest at Teluk Assam (H3) was most often limited to just once daily between 6:30 am and 9:30 am. This may partly due to the presence of tourists - walking, photographing, and watching them from the boardwalk - and inundation of the mangrove floor during high tides in this mangrove forest. When tourists were absent the group would access H3 twice daily between 6:30 am and 6:00 pm during low tides and on occasions three times. However, on a number of occasions the group was active in this forest until 11:00 am. On one occasion a juvenile was trapped by the high tide which submerged the mangrove floor. It remained in a mangrove tree at the mouth of Sg. Teluk Assam until the tide receded.

A total of 48 twelve-hour observations (576 hours) indicated that behavioural activity in the mangrove forest (H3) accounted for a monthly average of 24 per cent (Figure 5.13). An average of more than 17 per cent of behavioural activity occurred in mangroves whenever this study group of Proboscis Monkey came to mangrove forests once daily. However, mangrove forest activity accounted for 38 per cent when they came twice daily. Nevertheless these figures are less than those for the heath forests.

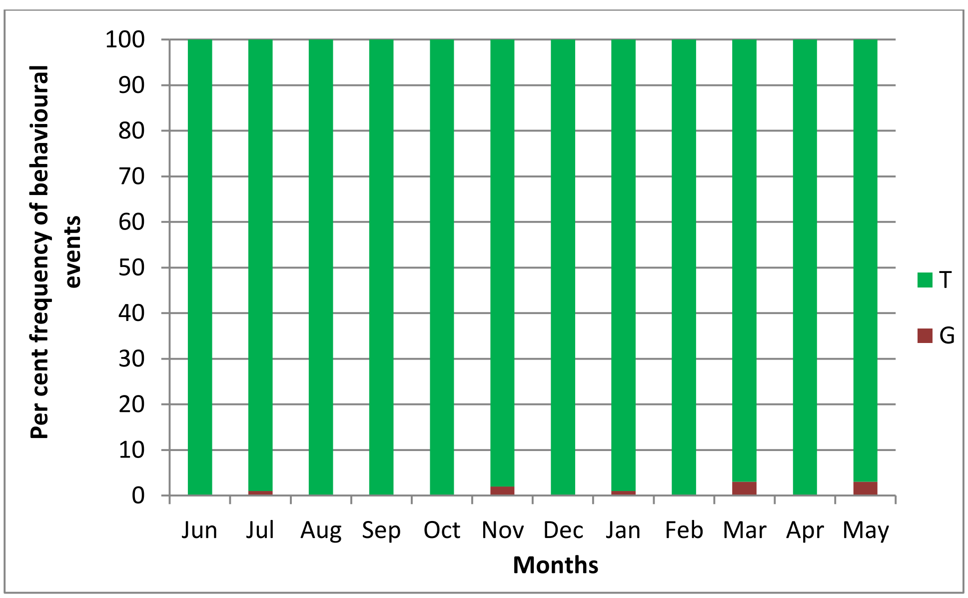


H – heath forests; M – mangrove forests

Figure 5.13: Monthly behavioural activities in both mangrove and heath forests

b. Kuching Wetland National Park

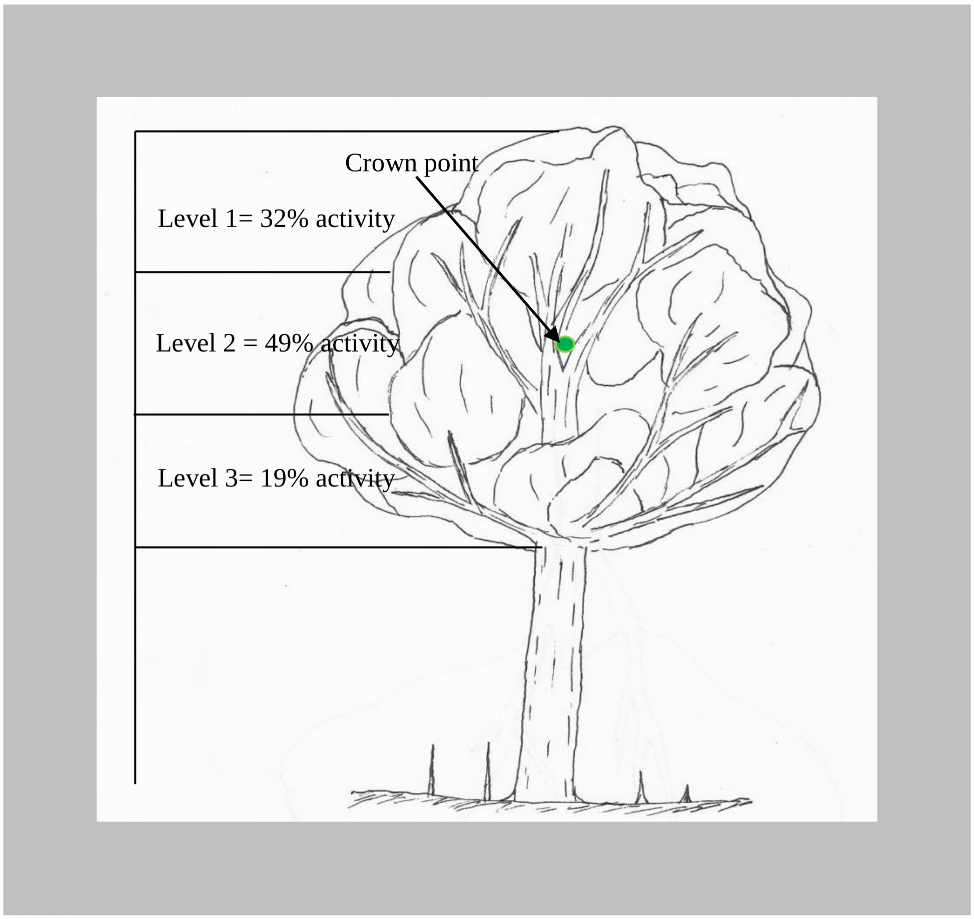
Tree and Ground Activity The behavioural activity of this study group of Proboscis Monkey most frequently occurred in trees, which accounted for 99 per cent of the recorded behavioural events (Figure 5.14). Ground activity occurred only in July, November, January, March and May which accounted for one per cent. Ground activity mostly happened during low tide when the mangrove forest floor was exposed. The group was exclusively active in the trees for seven months of the twelve-month study period - in June, August, September, October, December, February and April.



T – tree activity; G – ground activity

Figure 5.14: Location of behavioural activities according to month (Kuching Wetland National Park)

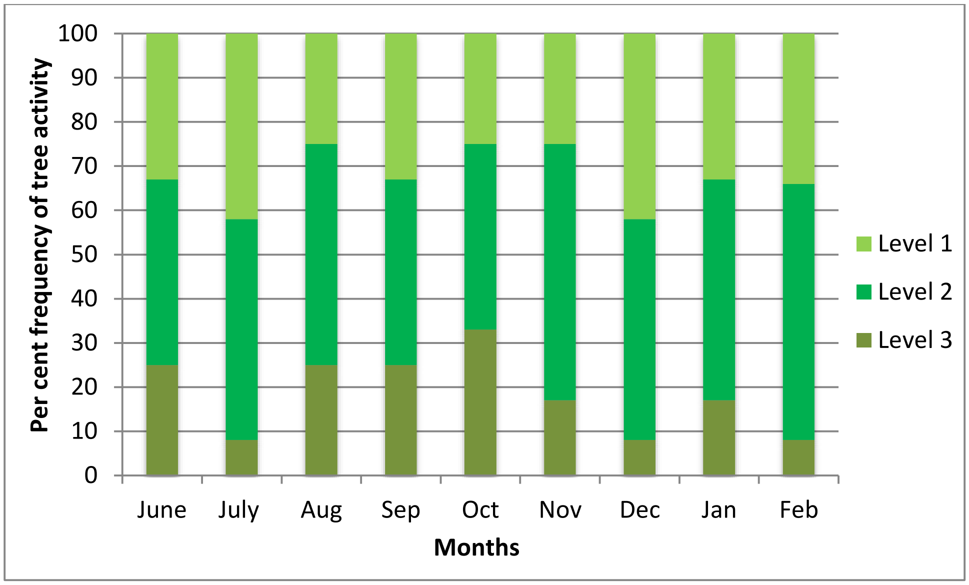
Most of the activities in the trees occurred within Level 1 and Level 2 of the tree crown which accounted for 32 per cent and 49 per cent respectively (Figure 5.15).



Level 1 – Top Level Crown, Level 2 – Middle Level Crown, Level 3 – Bottom Level Crown

Figure 5.15: Percentage of behavioural activities at different crown levels

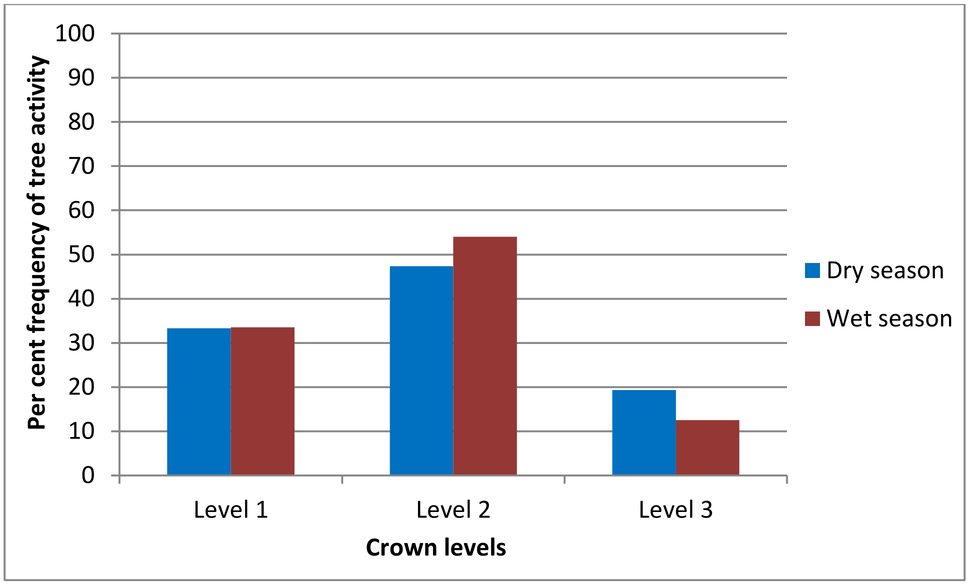
Monthly variation was evident with the highest record of tree activity in Level 1 (Top Level Crown) in July (42%) and December (42%), in Level 2 (Middle Level Crown) in November (58%) and February (58%), and in Level 3 (Bottom Level Crown) in October (33%) (Figure 5.16).



Level 1 – Top Level Crown, Level 2 – Middle Level Crown, Level 3 – Bottom Level Crown

Figure 5.16: Monthly tree activity at different crown levels

Seasonal variation in activity in Level 1 was not evident (33% dry and wet season) but there was a preference to use Level 2 during the wet season (54%) and Level 3 during the dry season (19%) (Figure 5.17). Analysis was only done from June 2011 to February 2012 because data from other months could not be used.



Level 1 – Top Level Crown, Level 2 – Middle Level Crown, Level 3 – Bottom Level Crown

Figure 5.17: Percentage of tree activity according to seasons

Behavioural Polygon

The daily path utilised by this study group of Proboscis Monkey rarely differed and ranged across the area between Sg. Pergam and Sg. Jebong. Occasionally, they were found crossing Sg. Jebong through crown connectivity during high tide.

Kuching Wetland National Park is dominated by mangrove forests and so the behavioural activity of this study group occurred within this single habitat which is characterized by different mangrove species interspersed across the landscape. Daily behavioural activity and hence home range was confined to these three behavioural polygons (see Figure 5.2 and Table 5.6). It most frequently occurred in *Sonneratia-Avicennia* communities in the central polygon which accounted for 83 per cent of the activities observed. In marginal and fundamental polygons, it accounted for 15 and 2 per cent respectively. *Sonneratia-Avicennia* communities were the dominant mangrove species compared to other species in the central polygon that formed a forest strip along the river edge at an average of 25 m in width from Sg. Pergam to Sg. Jebong.

The highest monthly record of behavioural activity within each of the polygons was 89 per cent in central polygon in November, 31 per cent in marginal polygon in September and 4 per cent in fundamental polygon in July (Figure 5.18).

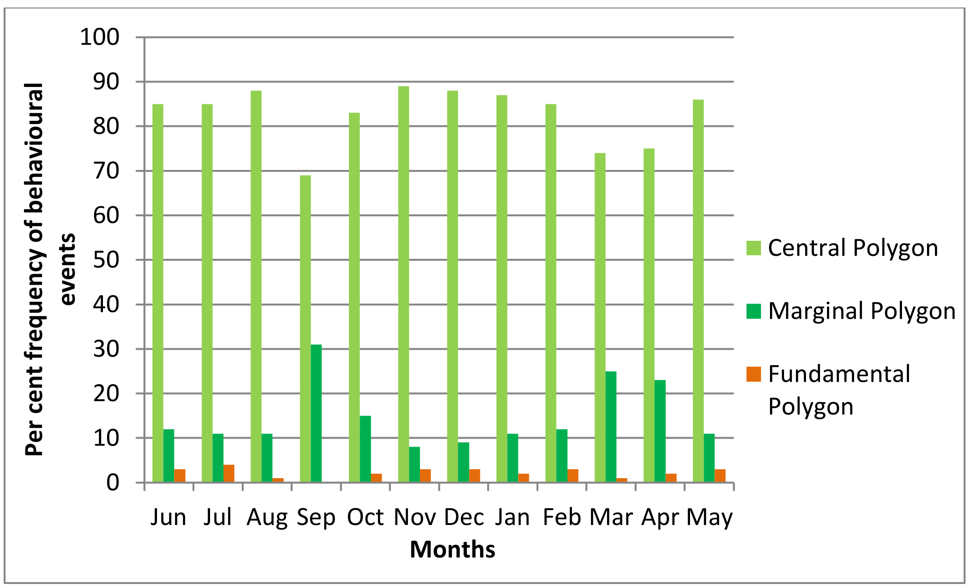


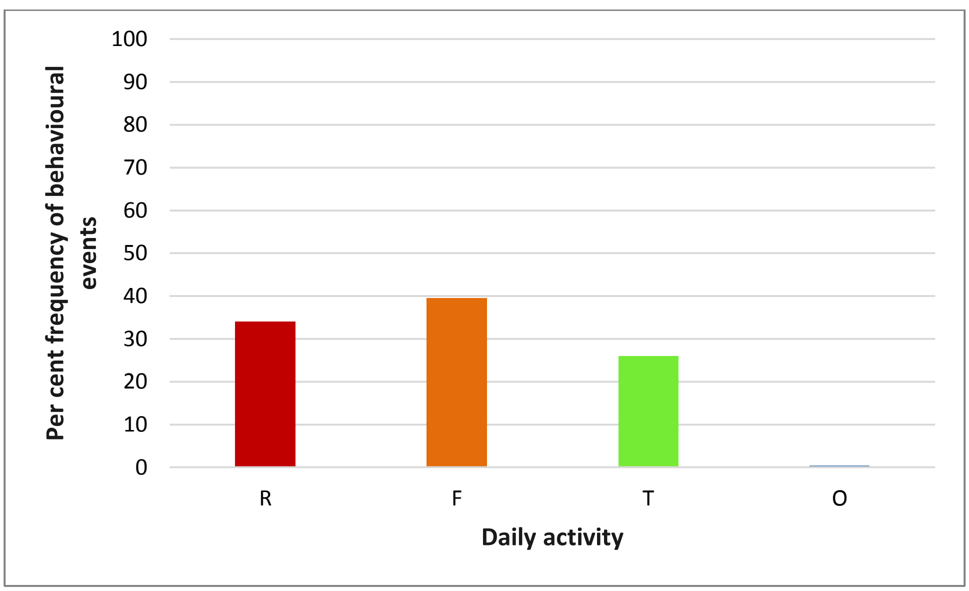
Figure 5.18: Monthly behavioural activities in different polygons

Heath forests are situated more than 600 m away from the central polygon. This study group was not found travelling from mangrove forests to heath forests during the study period. Longer periods of travel between habitats by crossing Sg. Pergam were not observed. However, one adult male from another group was found swimming across Btg. Salak during the study period (personal communication with Mohd Yani of Kg. Salak).

Daily Routine

a. Bako National Park

This study group of Proboscis Monkey most frequently engaged in *feeding* (39.6 per cent of events recorded; n = 5400 activity events performed for the whole study period). This was followed by resting which accounted for 34 per cent of the behavioural events recorded. The third most frequently occurring activity was travelling, which accounted for 26 per cent of the recorded events (Figure 5.19).



R = resting; F = feeding; T = travelling; O = Other activities

Figure 5.19: Per cent frequency of behavioural events performed by this study group of Proboscis Monkey in Bako National Park

Table 5.6 presents the mean and standard deviation of the per cent frequency in performing each activity by the study group of Proboscis Monkey.

Table 5.6: Per cent frequency of each activity in Bako National Park

	R	F	T	O
Mean ± SD (%)	34.0 ± 13.2	39.6 ± 14.7	26.0 ± 9.8	0.4 ± 1.2
Range (%)	5 - 56	7 - 75	10 - 50	0 - 6

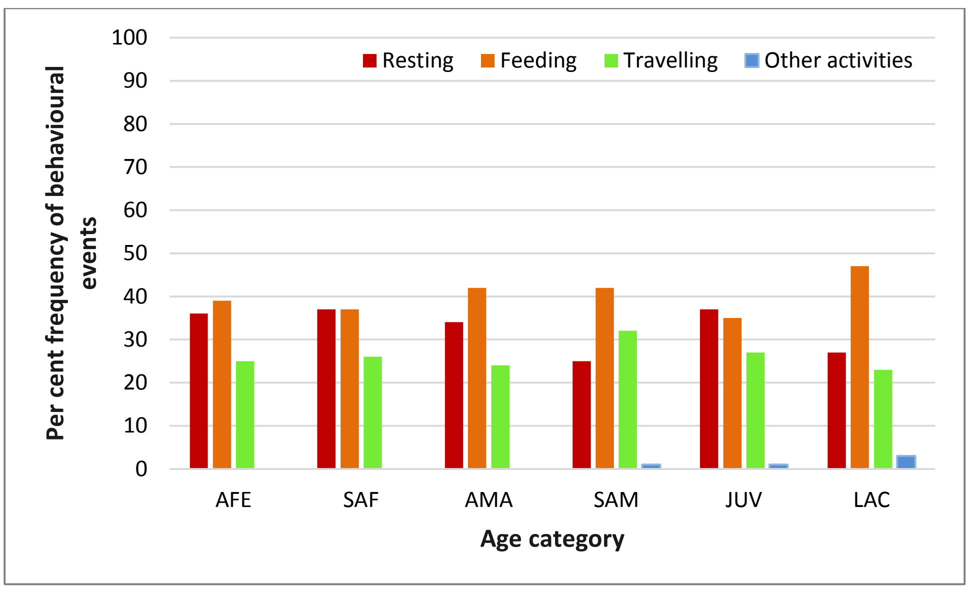
R – resting, F – feeding, T – travelling, O – Other activities

Age and Gender Variations

I sampled age categories of this study group of Proboscis Monkey for 12 hours a day (from 6:30 am to 6:30 pm) during a continuous observation period and combined this data for this part of the analysis. Observation less than 12 hours a day was taken out from this analysis to reflect only the core-study group of Proboscis Monkey's daily activity.

The daily activity pattern varied according to the age and gender categories of this study group (Figure 5.20). Except for sub-adult females and juveniles, all age categories most frequently engaged in feeding. Details of this feeding activity will be presented in Chapter 6.

Lactating Females Among these categories, lactating females engaged more frequently in feeding which accounted for 47 per cent of daily active events. However, there were no significant differences in the frequency of feeding between lactating females and each age category (p> 0.05) (although there was a significant difference when data for non-lactating and lactating females was combined – see below). Although lactating females were very selective in feeding (see Chapter 6), they also acquired more food, needed for daily activity and feeding their babies. Lactating females spent 27 per cent of their daily routine resting, 23 per cent travelling, and three per cent "other" activities.



AFE-adult female, SAF-sub-adult female, AMA-adult male, SAM-sub-adult male, JUV-juvenile, LAC-lactating

Figure 5.20: Per cent frequency of behavioural events performed by different age of this study group of Proboscis Monkey in Bako National Park

Males Adult male and sub-adult male Proboscis Monkey engaged in the same number of feeding events, (42 per cent). However, the adult male was found to be resting more frequently compared to sub-adult males (34 and 25 per cent respectively). Sub-adult males spent 32 per cent of their daily routine travelling, while for the adult male this was just 24 per cent. "Other" activities constituted one per cent of sub-adult males' daily routine, while the adult male did not engage in "other" activities.

Females Feeding activity by adult females accounted for 39 per cent of their daily behavioural events, while for sub-adult females this was 37 per cent. Adult and sub-adult females engaged in resting at a similar frequency, 36 per cent and 37 per cent, respectively. Adult and sub-adult females also travelled at a similar frequency, 25 and 26 per cent respectively. Neither category appeared to engage in "other" activities.

Overall, males (one adult male and a number of sub-adult males) of this study group of Proboscis Monkey more frequently engage in feeding compared to females (including lactating and non lactating females), which was significantly different ($n = 1716$; $\chi^2 = 95.11$, d.f. 1 $p < 0.001$). However, these females engaged more in resting and less travelling compared to males of the same study group. These variations were significantly different (resting: $n = 1391$; $\chi^2 = 19.1$, $p < 0.001$; travelling: $n = 1085$; $\chi^2 = 49.18$, $p < 0.001$).

Juveniles Because it was hard to differentiate between male and female juveniles of this study group of Proboscis Monkey, the data represents the age category only, juveniles, regardless of gender. Juveniles engaged in all activity categories. They most frequently engaged in resting (37%). Feeding accounted for 35 per cent, travelling accounted for 27 per cent and "other" activities just one per cent of their daily routine events.

b. Kuching Wetland National Park

Table 5.7 outlines the mean and standard deviation of per cent frequency of behavioural events performed by this study group of Proboscis Monkey for each defined daily activity.

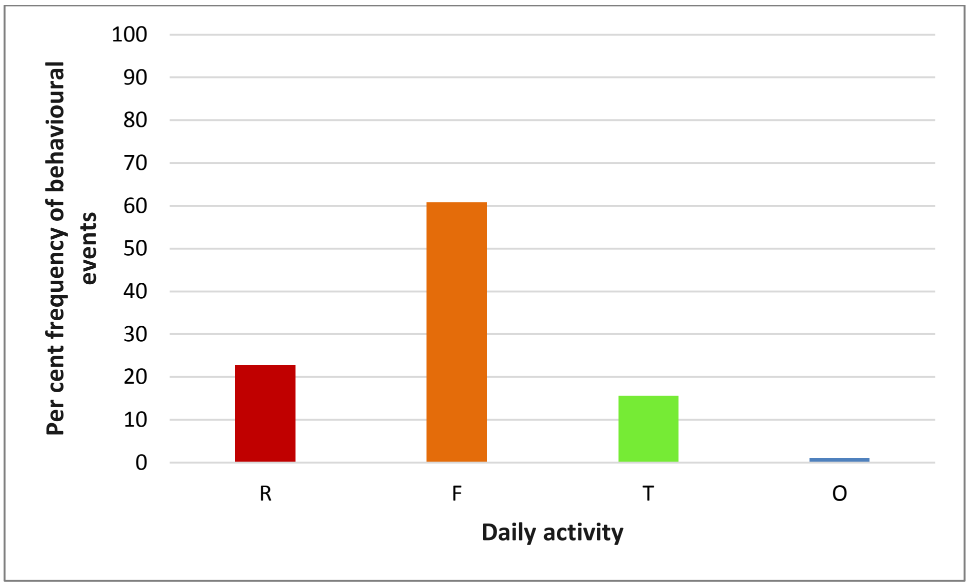
Table 5.7: Per cent frequency of each activity in Kuching Wetland National Park

	R	F	T	O
Mean ± SD (%)	22.7 ± 11.3	60.7 ± 17.5	15.6 ± 10.5	1.0 ± 3.0
Range (%)	4 - 42	17 - 93	3 - 43	0 - 17

R – resting, F – feeding, T – travelling, O – Other activities

Similar to Bako National Park, the study group of Proboscis Monkey in Kuching Wetland National Park most frequently engaged in feeding (Figure 5.21), which accounted for more than 60 per cent of the recorded behavioural events (n=3598 activity events performed for the whole study period). However, significantly more feeding events were recorded for this study group compared to the Bako National

Park study group (n = 60; z = -3.908, $p < 0.001$). They engaged in resting for 23 per cent of the daily routine, 15 per cent in travelling. Similar to Bako National Park, "other" activities occupied a small component of this study group's behavioural events, being just one per cent of their daily routine.

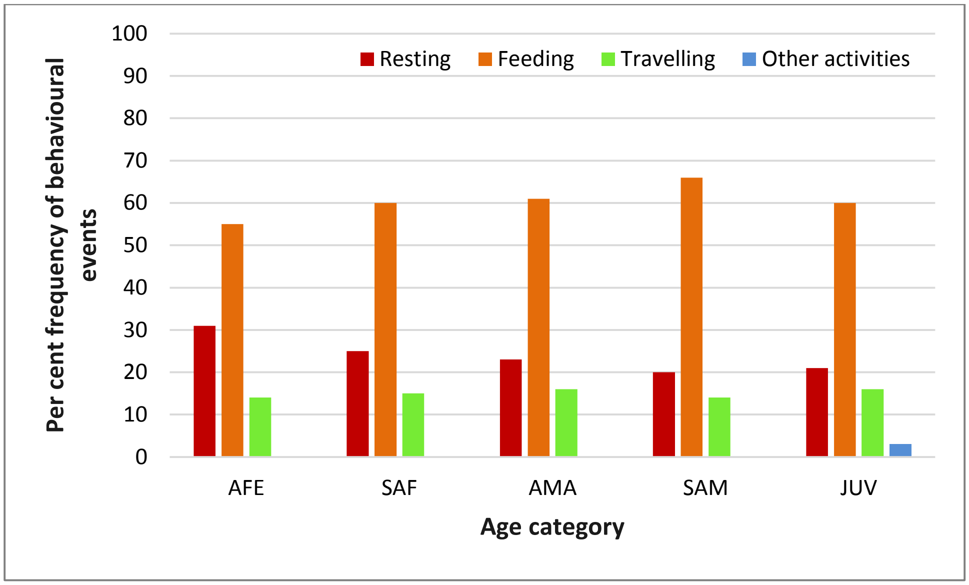


R = resting; F = feeding; T = travelling; O = Other activities

Figure 5.21: Per cent frequency of behavioural events performed by this study group of Proboscis Monkey in Kuching Wetland National Park

Age and Gender Variations

For this study group of Proboscis Monkey, differences in daily behavioural patterns according to age and gender categories were evident (Figure 5.22).



AFE-adult female, SAF-sub-adult female, AMA-adult male, SAM-sub-adult male, JUV-juvenile

Figure 5.22: Per cent frequency of behavioural events performed by different age of this study group of Proboscis Monkey in Kuching Wetland National Park

Males Sub-adult males displayed the highest frequency of feeding events of all the age and gender categories which accounted for 66 per cent of their daily behavioural events. Resting and travelling accounted for 20 per cent and 14 per cent respectively, while they did not engage in "other" activities. The adult male engaged slightly less frequently in feeding (61%). However, it engaged more frequently in resting and travelling compared to sub-adult males. The adult male's resting and travelling activities accounted for 23 per cent and 16 per cent of the daily behavioural events recorded respectively. Similar to sub-adult males, the adult male did not perform "other" activities in their daily routine.

Females Among the female Proboscis Monkey, sub-adult females engaged most frequently in feeding (60%) and less frequently in resting (25%), and travelling (15%). Adult females on the other hand engaged 55 per cent of their daily routine in feeding. They engaged more frequently in resting compared to sub-adult females, which accounted for 31 per cent of their daily behavioural events, but slightly less frequently in travelling, (14 per cent of behavioural events). Both adult females and sub-adult females did not engage in "other" activities.

Male Proboscis Monkey engaged more frequently in feeding compared to females. This variation was significantly different (n = 1404; χ^2 = 165.473, d.f. 1 $p < 0.001$). They engaged an equal per cent frequency of their daily routine in travelling. However, female Proboscis Monkey engaged more frequently in resting compared to male Proboscis Monkey which was significantly different (n = 347; χ^2 = 35.507, d.f. 1 $p < 0.001$).

Juveniles Juveniles engaged 60 per cent of their daily routine in feeding, as did the sub-adult females. Their resting activity accounted for 21 per cent of their daily behavioural events, and travelling 16 per cent. Among the age and gender categories, only juveniles engaged in "other" activities in their daily routine, occupying three per cent frequency of their behavioural events.

Monthly Routine

a. Bako National Park

Monthly Activity of Combined Age Categories

Feeding This study group of Proboscis Monkey most frequently engaged in feeding in Bako National Park in July 2011 (Figure 5.23), which accounted for 60 per cent of their combined activity for that month. This was followed by August (52%), September (51%) and November 2011 (51%). The least feeding activity was evident in May 2011 (20%) and April 2012 (26%). There was a significant difference between the highest number of feeding events in July 2011 and the lowest in May 2011 (n = 100; z = -9.764, $p < 0.001$), and also between July 2011 and April 2012 (n = 162; z = -11.029, $p < 0.001$).

Resting For seven months, resting accounted for over 35 per cent of their behavioural events - May 2011 (47%), followed by October 2011 (44%), March 2012 (40%), April 2012 (40%), January 2012 (39%), May 2012 (37%) and Jun 2011 (35%). The least resting occurred in July 2011 (6%) during which month feeding activity was highest (60%). There was a significant difference between the highest number of resting events in May 2011 and the lowest in July 2011 (n = 100; z = -9.764, $p < 0.001$). During May 2011, the highest evident resting period (47%), the record of feeding activity was the lowest (20%), whereas in October 2011 the record of travelling activity was lowest (17%).

Travelling The most frequent travelling activity occurred in August 2011 (37%) and the least was undertaken in October 2011 (17%). The variation in travelling between these two months was significantly different (n = 311; z = -13.077, $p < 0.001$).

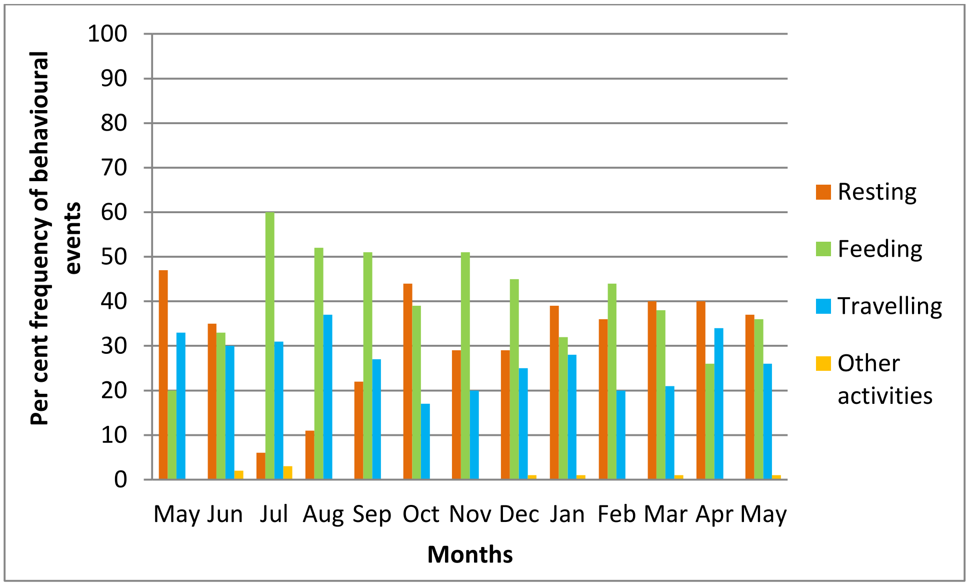


Figure 5.23: Monthly per cent frequency of defined events performed by combined age categories of this study group of Proboscis Monkey in Bako National Park

"Other" activities were the least performed activity that this study group of Proboscis Monkey engaged in monthly over the study period. "Other" activities were only performed in July 2011 (3%), Jun 2011 (2%), December 2011 (1%), January 2012 (1%), March 2012 (1%) and May 2012 (1%).

b. Kuching Wetland National Park

Monthly Activity of Combined Age Categories

Feeding These study animals engaged more frequently in feeding (Figure 5.24) compared to resting, travelling and "other" activities per month over the study period, except in June 2011 (34%). The highest per cent frequency of active feeding was in May 2012 (79%), followed by February 2012 (75%) and April 2012 (73%). Variation between the highest and lowest feeding in May 2012 and June 2011 was significantly different (n = 152; z = -10.146, $p < 0.001$).

Resting Resting was the second most frequent daily activity performed by this study group of Proboscis Monkey. The highest per cent frequency of resting activity occurred in June 2011 (34%) during which the lowest frequency of feeding activity (an equivalent 34%) was recorded. The second highest frequency of resting was in January 2012 (32%). The least per cent frequency of resting occurred in May 2012 (10%), the month when feeding activity was the highest (79%). Variation between the highest and the lowest frequency of resting in June 2011 and May 2012 was significant difference (n = 152; z = -10.185, $p < 0.001$).

Travelling The most frequent travelling activity occurred in July 2011 (35%) and the least was undertaken in December 2011 (7%). The variation in travelling between these two months was significantly different (n = 167; z = -11.325, p< 0.001).

This study group spent a very small per cent frequency of daily routine engaged in "other" activities. The highest record for "other" activities they performed was in August 2011 (5%).

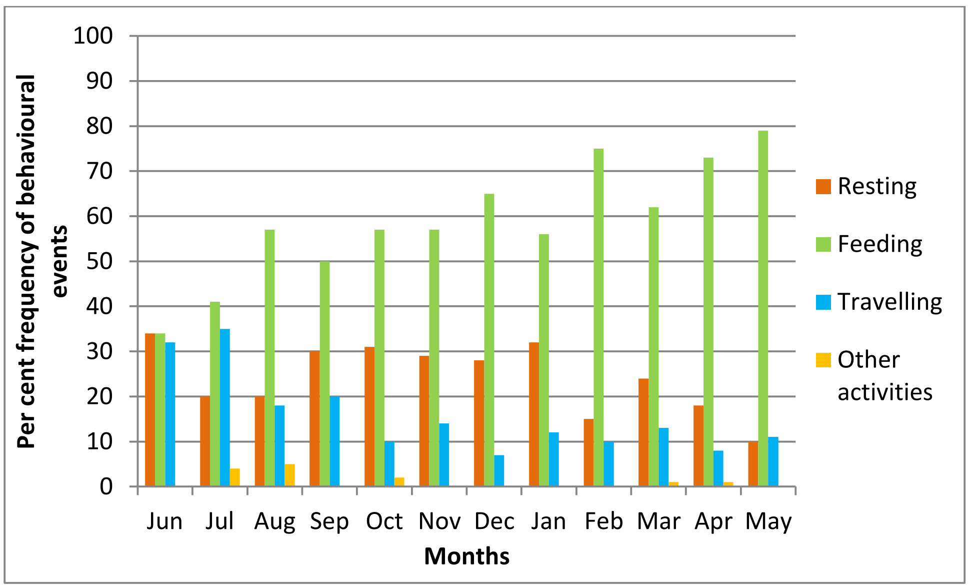


Figure 5.24: Monthly per cent frequency of defined events performed by combined age categories of this study group of Proboscis Monkey in Kuching Wetland National Park

Seasonal Variations

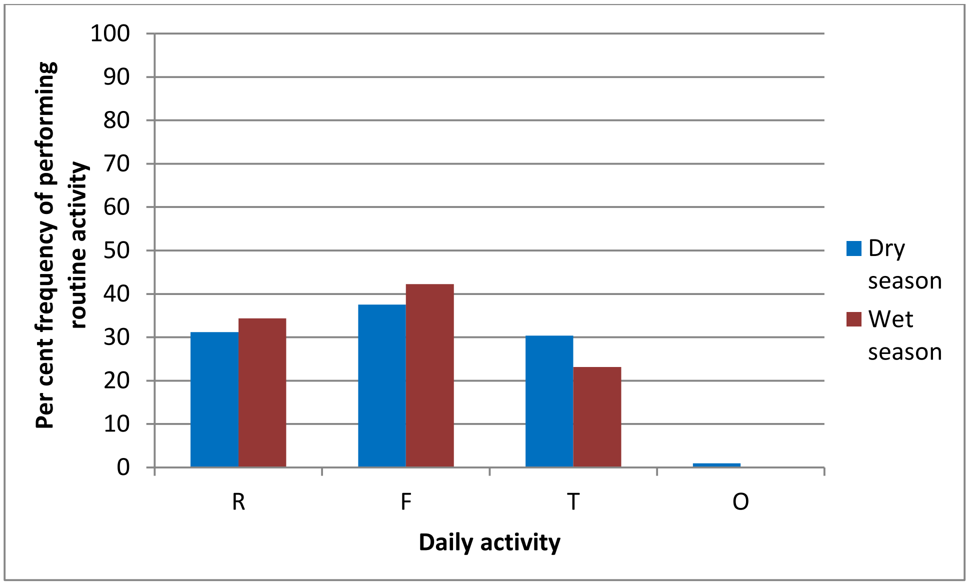
a. Bako National Park

Feeding A significant difference was evident for feeding activities performed during the wet and dry season (n = 1398; χ^2 = 10.65, d.f. 1, p = 0.001). Figure 5.25 shows that this study group of Proboscis Monkey engaged more frequently in feeding during the wet season (42%; n = 1800 activity events performed) compared to the dry season (37%; n=1700 activity events performed).

Resting The most frequent resting activity occurred during the wet season (34%) as opposed to the dry season (31%). The difference in resting activity between these two seasons was significantly different (n = 1149; χ^2 = 6.89, d.f. 1, p = 0.009).

Travelling A statistically significant variation was also evident for travelling activity between the wet and the dry seasons (n = 932; χ^2 = 10.73, d.f. 1, p = 0.001). The travelling activity occurred most frequently during the dry season (30%) as opposed to the wet season (23%).

This study group did not engage in "other" activities during the wet season but they did engage in "other" activities during the dry season (1%).



R – resting, F – feeding, T – travelling, O – Other activities

Figure 5.25: Seasonal routine behavioural events in Bako National Park

b. Kuching Wetland National Park

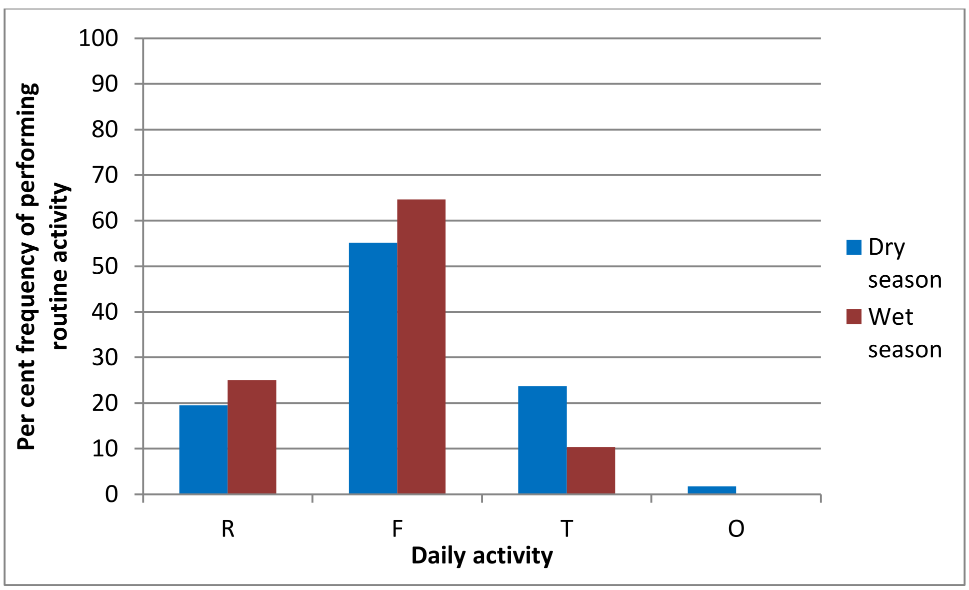
The activity pattern of the study group of Proboscis Monkey in Kuching Wetland National Park during both wet and dry seasons was slightly different to that of Bako National Park (Figure 5.26).

Feeding The Kuching Wetland National Park study group was much more active feeding during the wet (64%) season (n = 1199 activity events performed in wet season) compared to the dry (55%) season (n = 1300 activity events performed in dry season). However the variation of feeding activity between the wet and the dry seasons was not significantly different (n = 1492; χ^2 = 2.25, d.f. 1, $p > 0.05$).

Resting They engaged more frequently in resting during the wet season (25%) compared to the dry season (19%) and this variation was significantly different (n = 553; χ^2 = 3.99, d.f. 1, p = 0.04).

Travelling They engaged more frequently in travelling during the dry season (24%) compared to the wet season (10%) and this variation was significantly different (n = 25; z = -2.723, p< 0.01).

Furthermore, whilst they did not engage in “other” activities during the wet season they did engage in “other” activities during the dry season (2%).



R – resting, F – feeding, T – travelling, O – Other activities

Figure 5.26: Seasonal routine behavioural events in Kuching Wetland National Park

5.4 DISCUSSION

5.4.1 Behavioural Patterns

Daily behavioural patterns in specific study site

a. Bako National Park

Daily behavioural activity of this study group of Proboscis Monkey differed according to habitat types which could be attributed to habitat charisteristics, environmental variables and human activities. This difference was evident when the monkeys' daily use of both heath and mangrove forests varied with most activity occuring in the heath forests (H1 and H2). At this study site quality of habitat in relation to habitat charisteristics such as forest structure, availability of resources and food plants, may partly explain the differences in habitat use (Wasserman et al., 2010). Heath forest, which was classified as the medium closed heath forest in this study, provided a relatively intact forest structure (canopy connectivity, etc; see Chapter 4), suitable food plants (see Chapter 6), and less direct exposure to tourists (see Chapter 7). With regard to habitat characteristics, canopy connectivity here may have provided some choices of routes to traverse from tree to tree, allowing for ease of movement and safety. However, the interface between the heath and the mangrove forest that forms a forest gap in terms of continuity of canopy was a factor in the need for the animals to venture down to the ground and cross over the forest floor. This structural variation of the forest in this portion of the landscape affected the monkeys' movements, requiring a change in behaviour in order to meet their needs for essential resources. The effect of structural and spatial variation in habitat quality on the habitat use of wildlife including primates have been reported earlier in other research for example Arroyo-Rodriguez and Mandujano (2006), Chapman et al. (1989), Holzkamper et al. (2006) and Lindenmayer (2000).

The heath forest is characterized by different strata such that daily routes have to negotiate an undulating canopy. The direction of these movements may not be perpendicular, but parallel to the gradient or contour lines because it is too steep and difficult for the study group move otherwise. This was evident when the anti-clock wise movements (from north-west at Paku Trail to south-west at Teluk Assam and south-east at Lintang-Paku Trail) of the study group mirrored the contour lines.

In the mangrove forest (H3 – coastal mangrove), the structure and extent of the forest (see Chapter 4), and the resources available to the animals (Chapter 6) differed to that of the heath forest which may party explain the lower occurrence of behavioural activity in this habitat. This habitat differed in vegetation composition (less species richness; less dense), quantity of food resources were less and connectivity was reduced (see Chapters 4 and 6), all habitat quality attributes known to effect primates (Arroyo-Rodríguez et al., 2007; Asensio et al., 2009; Pyritz et al., 2010). Low density of food plants in particular is known to result in low probability of occurrence of primates (Marshall, 2009).

Environmental variables may also explain difference in habitat use. In the mangrove forest the monkeys had to speed up their activity before the mangrove floor was submerged by the high tide. This would have limited the time available to them for foraging, whereas heath forests were not subjected to such environmental events. A third possible explanation is human activity. In the mangrove forest they also had to cope with tourism activity on the boardwalk. Although they are habituated to human presence (Budeng, 2004), they appear intolerant of certain tourist activity (this will be discussed further in Chapter 7). This combined with limited protection due to forest structure would leave the animals vulnerable.

After being displaced from the mangrove forests, they always rested at the habitat edge between mangrove forests (H3 - coastal mangrove) and heath forest (H1 – medium closed heath forest). This habitat edge served as a naturally forested connection zone between the heath and mangrove forests. It also acted as natural refugia, a place to retreat to and survey the surroundings. It also contained a number of food plants and so provided some foraging opportunities. The role of refugia is of great importance for the protection of wildlife in heavily-visited national parks, although it is often a human-made refugia (Campbell et al., 2011). The use of this habitat edge was not only protecting them from human disturbance but also reducing the travel cost, in that they did not need to travel a long distance to find a safe place. However, behavioural activity in this habitat edge was considered within the medium closed heath forest because the habitat characteristics including vegetation composition, availability of resources were similar as in the medium closed heath forests. From this habitat, the study group either returned again to the mangroves or moved further into the heath forests. As the human disturbance in the coastal mangrove (H3) was more prevalent due to the presence of visitors on the boardwalk, the study group always inclined to move further into the heath forest especially Habitat 1. Apart from this the quality of resources in Habitat 1 may suggest the high occurrence of behavioural activity in this habitat compared to other habitat use categories.

Safety considerations could underline other aspects of behavioural activity that the study group performed especially daily changes to sleeping sites and the groups sleeping position in the canopy. Geographical variables, landscape patterns, crown connectivity and food distribution (Chapman, 1989; Twinomugisha & Chapman, 2007) are all potential reasons for the study group locating their sleeping positions in the heath forests. An early report by Bennett (1993) claimed that Proboscis Monkey did not sleep in good trees. From this study there was no evidence that the study group did not sleep in good trees. "Good trees" is a term that refers to healthy trees with full crown cover. This study group chose open and out reaching branches of healthy trees for sleeping which were not less than 10 m above the ground. Among these trees were their food plants including *Shorea* spp., *Syzygium* spp., *Garcinia* spp., *Pentace* sp., *Vitex* sp., and *Calophyllum* sp. There was no incidence of the study group being attacked by a predator but the presence of python (*Python reticulates*) may explain the continuing changes to their sleeping sites. Being a leader of the study group an adult male mostly slept at the higher crown canopy compared to other group members. The reasoning for this is uncertain but may have to do with protection of the group through surveillance.

Besides safety considerations, the availability of resources in different forest strata may explain why behavioural activity was more frequent in 1st and 2nd strata as opposed to 3rd stratum. The top (1st) and middle (2nd) strata of the forest may provide more food items preferred by the monkeys, especially young leaves (Harris et al., 2010; Hladik, 1978b; Isbell, 1991; Lowman & Moffett, 1993). The upper canopy of this forest type had some dominant trees that formed 1st and 2nd forest stratums. This type of forest structure is mostly preferred by folivorous primates that spend most of their daily activities in the upper canopy (Asensio et al., 2009; Bitty & McGraw, 2007; Chapman et al., 2002; MacKinnon & MacKinnon, 1980). This may explain the similar frequency of behavioural activities in the upper canopy during the wet and the dry seasons in spite of the evident seasonal variation in each specific behavioural activity (feeding, travelling and resting) between these two seasons.

b. Kuching Wetland National Park

The study group of Proboscis Monkey in Kuching Wetland National Park lives predominantly in one type of forest habitat, the mangrove stands which are mostly uniform in structure and growth, and provides an even canopy. This habitat attributes may facilitate behavioural activity which mostly occurred in trees. Their preferred habitat appears to be a riverine mangrove strip that stretches in between Sg. Pergam and Sg. Jebong, according to the daily behavioural activities recorded in this study. This habitat is dominated by the most preferred food plant for the study group (*Sonneratia alba*; food plants will be discussed further in Chapter 6). The forest structure in this habitat was also good (refer to Table 4.21 of Chapter 4) in that it provided all the requirements for the monkeys (Curtis & Rasmussen, 2006) in relation to the high quality of resources preferred by primates (Marshall, 2009; Marshall et al., 2009).

The difference in frequency of behavioural activities in each crown level of the trees may be explained by the distribution and availability of resources seasonally. The frequency of behaviour activities was higher in Level 2 of tree crown during the wet season. This is consistent with the timing of production of new mangrove leaves during the wet season (Coupland et al., 2005). It may also be partly due to this being a time of severe flooding of the forest floor and lower levels of the forest vegetation.

Their daily movement pattern in the canopy was similar as they followed the same route which suggests the monkeys have the ability to navigate the environment using cognitive maps, an recognized ability of other primates (Boyer et al., 2006). The canopy connectivity in this habitat not only provided ease of movement via arboreal routes but locomotion security by reducing the possibility of predation (Curtis & Rasmussen, 2006; da Silva Junior et al., 2010; Fimbel, 1994).

Human disturbance was minimal but occasionally the study group was seriously disturbed by the presence of a tourist boat, evident in their rapid multi-directional movements away from the foraging area. When disturbance occurred on a particular day, they escaped beyond the central polygon across the Sg. Jebong or into the middle of marginal polygon. However, they came back to the central polygon which was their most preferred habitat, when there was no more occurrence of disturbance during the day.

Availability and distribution of food resources (Chapman et al., 2010; Milton, 1980) may explain why the study group most often engaged in behavioural activity in the central polygon, especially near the coastal edge and the river bank. This habitat type may provide the high quality of resources essential for monkeys (Marshall, 2009; Marshall et al., 2009), because it has an abundance of preferred food plant species (Chapter 6) and a suitable forest structure (Chapter 4), as well as trees which provide sleeping sites. Very often the study group chose their sleeping sites in the central polygon or in between the central and marginal polygon. They even fed on the trees they slept in which were among their preferred food plants. Therefore, the assertion that the monkey do not feed on the tree they slept in (Bennett & Gombek, 1993) is no longer valid.

Comparison of two study sites

The separate study groups of Proboscis Monkey demonstrated different behavioural activity patterns in Bako National Park compared to Kuching Wetland National Park. Daily behavioural patterns appeared to be influenced by habitat characteristics at both study sites as opposed to social grouping, as they all foraged in a group. As reported earlier, foraging in this way is the natural social behaviour of Proboscis Monkey (Bennett & Sebastian, 1988; Murai, 2004; Onuma, 2002; Sha et al., 2008) and of other primates (Little & Sommer, 2002; Schülke, 2001; Yan, 2012). On the other hand, environmental variables and human activities together with habitat characteristics may have had more of an influence on behavioural activity in the different habitat types in Bako National Park than in Kutching Wetland National Park. The two study sites are ecologically and administratively different, which would influence the behavioural patterns according to habitat type of each study group. Of particular significance to differences in behavioural activities is that whilst the study group in Bako National Park is more habituated to human presence with many tourists engaged in daily tourism activity they are nevertheless affected by their presence, evident in the reduced behavioural activity in the habitat most exposed to tourists, the mangrove forest (exposure in terms of number of tourists, frequency and length of exposure to them and openness of the forest). The study group in Kuching Wetland National Park is less habituated with limited tourism activity encroaching into the area. So they are less often in contact with people, fewer people involve, and when it does occur it is for less time. While the presence of tourists results in a sudden eratic escape response, the Proboscis Monkey appears less disturbed in the long term, soon returning to their preferred foraging area.

The ecologically different habitats in both study sites also show that they have different choices of preferred sleeping sites and sleeping positions. A previous study in Sabah that related to preferred sleeping sites of Proboscis Monkey (Bernard & Hamzah, 2006; Bernard et al., 2011; Boonratana, 2000; Matsuda, Tuuga, & Higashi, 2010; Sha et al., 2008) showed that sleeping mostly occurred in the homogenous habitats, but no reporting on sleeping position in different stratums and crown levels was available. Variation in canopy architecture and crown connectivity between the study sites may also be linked to the different behavioural patterns of the study groups. Before this study, there was no report on the influence of canopy connectivity on Proboscis Monkey foraging activity. However, canopy connectivity is needed by arboreal primates that mostly depend on forest stands and canopy structure for daily foraging activity and movement (Hopkins, 2011; Madden et al., 2010).

Given the circumstances of both study sites, behavioural activity patterns of the study groups may likely be changed over time due to human disturbance, which have been reported to have an influence on the behaviour of primates (Chauhan & Pirta, 2010; McCarthy et al., 2009). The influence of human disturbance on behavioural activity of the monkeys in these two habitats is unavoidable because they share the same habitats. As with this study, habituation was obviously seen as a direct result of human influence. While human-Proboscis Monkey conflict has yet to occur, Long-tailed Macaques (*Macaca fascicularis*) have been observed acting aggressively to gain access to human food in Bako National Park (incidental observation).

5.4.2 Behavioural Routine

Behavioural routines in specific study site

a. Bako National Park

Behavioural routine involved feeding, resting, travelling and 'other' activities. Among these activities, feeding was the most important behavioural event for Proboscis Monkey in this study group. This may be related to nutritional requirements of Proboscis Monkey and availability of quality resources in the study site to fulfil their daily needs. Although they would sometimes need to travel to feed, this group did not engage in much travelling as food sources were found in the same habitat as where they slept. This was evident on a number of occasions where Proboscis Monkey were found sleeping in their preferred food plants in heath forests, for example *Syzygium* sp. and *Garcinia* sp. On most occasions Proboscis Monkey took more than 30 minutes sitting on one branch during feeding before they moved to the next branches in a single tree, which equated to less travelling. A previous study revealed that Proboscis Monkey's sleeping sites are close to their food resources (Bennett & Gombek, 1993). They might increase travelling activity when there is a lack of high-quality foods (Bennett & Sebastian, 1988) which is dependent on habitat types (Bennett & Sebastian, 1988; Boonratana, 2000; Matsuda et al., 2009b).

Frequency of feeding, resting, travelling and 'other' activities differed among age and gender categories in this study. More feeding events evident in the adult male and sub-adult males may be related to their body size. Body size was an important factor affecting activity budget in a previous study on other primates (Fleagle & Mittermeier, 1980) and is also related to metabolic rate (Ross, 1992; Schmid & Speakman, 2000) as well as habitat quality (Snaith & Chapman, 2007; Struhsaker et al., 2004) As body size of male Proboscis Monkey is much larger than female, this may explain why it engaged in more feeding activity. Besides body size, feeding competition may not happen as food resources are not limited and as a result no female dominance hierarchies are formed to defend access to food resources (Snaith & Chapman, 2007). Male and female Proboscis Monkey also differed in frequency of resting and travelling with males engaging in more travelling and less resting than females. Due to their apparent need for more food, males Proboscis Monkey may have to travel more to find more food as opposed to females. Although feeding is important, sub-adult females and juveniles engaged more in resting. This may also be related to their body size compared to their adult and sub-adultmale counterparts, in spite of the fact that young individual primates still have insufficient skill and experience to search for food and have to learn from their adult counterparts. Learning foraging techniques through imitation of adults is an important social-learning technique for young individual primates (Rapaport & Brown, 2008). In this context juveniles may need extended periods to learn from experienced and older members in this study group. Future research may focus on exploring in further detail social-learning techniques among Proboscis Monkey. In contrast, lactating females engaged more in feeding, which may be related to increased resource requirements for their own babies. Most folivorous primates need to maintain their energy balance requirements by engaging in more feeding (feeding on high quality of food). This is a behavioural strategy to avoid nutrient deficiency (Wasserman & Chapman, 2003), which directly links to nutritional requirements as a result of the high metabolic costs associated with gestation and lactation (Bates & Byrne, 2009; Lee et al., 1991).

Behavioural routine patterns also exhibited monthly variations in feeding, resting, travelling and 'other' activities. Feeding was at the highest frequency in July and the lowest in May, suggesting that considerable change in either food requirements and/or food availability occurred within this period. This feeding behaviour seemed to follow tropical rain forest phenology and productivity where availability of resources increase in July during the dry season till early the wet season in November (Moreau et al., 2010) with minor phenophases from March to May (Staggemeier & Morellato, 2011). In contrast, a considerable change in resting also occurred in similar period, May and July, where highest frequency of resting occurred in May (lowest feeding frequency) and lowest in July (highest feeding frequency – less time available to rest). The higher frequency of resting activities in certain months suggests the need to preserve energy in relation to availability of resources (Snaith & Chapman, 2005, 2007). Proboscis Monkey needed to travel more in August partly due to patchy distribution of resources in space and time, and also varying nutritional quality (Snaith & Chapman, 2007) and hence travel time increases to enable consumption of an equivalent amount of food. This is consistent with Hoffman and O'Riain (2011) who suggest that more travelling in certain months of the year is associated with the need to satisify nutritional requirement of primates due to sparsely distribution of resources. This association is supported by the highest frequency of feeding being observed during the wet season. The least frequency of travelling in October was commensurate with less feeding during the dry season.

Feeding, resting, and travelling events were significantly different between the wet and the dry seasons. More feeding during the wet season suggests that more abundant and higher quality of resources during this season (see Chapter 6) and thus the consumption increases due to availability of food resources. The highest frequency of travelling being observed in the dry season may relate to the lowest resting during the wet season, partly due to variation in the availability of resources according to seasons. The availability of resources and metabolic requirements may have an influence on behavioural events. While digestibility (Clauss et al., 2008) is related to metabolism, temporal and spatial variations in resources were reported to have effects on activity budgets in other primate studies (Brugiere et al., 2002; Tsuji, 2010). Therefore, availability of resources may not evenly distribute in this study in relation to both seasons apart from metabolism which affects behavioural routine of Proboscis Monkey.

b. Kuching Wetland National Park

Feeding was also the most frequently observed behavioural event for the monkeys in Kuching Wetland National Park and this was more frequent than their counterparts in Bako National Park. This explains that feeding was the most important activity budget in the riverine mangrove of Kuching Wetland National Park which provided suitable habitat for behaviuoral activities. Quality habitat that characterised by good forest structure and abundance of the preferred food plants (see Chapter 4) may also explain higher feeding activity in this riverine mangrove. Higher proportion of feeding than other behavioural activities in this study is consistent with a previous study in Sarawak (Salter et al., 1985) and with another primate study (Md-Zain & Ch'ng, 2011) which demonstrated that feeding was the greatest proportion of activity budget of monkeys. Human interruption of behavioural activity in Kuching Wetland National Park was limited, such that the monkeys stayed longer engaging in feeding. Tourist boats were present for only one or two hours during high tides, and harvesting of mangrove trees occurred outside the behavioural polygons. As the food sources were close to sleeping sites, the monkeys did not engage much in travelling suggesting their food requirements were met by the resources available within close proximity. Proboscis Monkey needed to engage more in resting than travelling because resting can preserve their energy (Snaith & Chapman, 2007). This has occurred among the primates, especially folivorous primates, because they have a strategy to maintain an energy balance through reduced basal metabolic rate (McNab, 1978). This may also possibly occur with Proboscis Monkey which is suspected to have the lowest metabolic rate of any colobine (Chivers, 1994; Chivers & Hadlik, 1980; Dierenfeld et al., 1992).

Variations in behavioural events are related to resources requirement among age and gender categories. Feeding was the most important activity budget for all age and gender categories. However, more feeding was performed by males (adult male and subadult males) as opposed to females may relate to their body size (Fleagle & Mittermeier, 1980) and nutritional requirements (Hoffman & O'Riain, 2011). Both males and females engaged with equal frequency in travelling which may have been linked to the strictly maintained intrinsic bond among individuals. Females engaged in more resting than males. This suggests that males are more active than females. Males may have to integrate daily activity with the protection of group members within the behavioural periphery. Apart from this, resting is a behavioural strategy of primates to preserve energy, which is related to metabolic cost and likewise, most of a females' movement is always associated with feeding requirements (Bates & Byrne, 2009). Juveniles engaged in more feeding may be partly due to different distribution and availability of food sources in mangrove habitat of Kuching Wetland National Park from heterogeneous habitat of Bako National Park. This also implies that juveniles' period of learning from older members in this study group is shorter and access to high-quality resources may be much easier in a single type of habitat.

In certain months of the year Proboscis Monkey engaged in more feeding events, especially May, February and April (in descending order). This may suggest that distribution of resources varies and food sources are easy to find apart from feeding requirements during these months. Feeding in June was the lowest frequency observed and was commensurate with the highest frequency of resting events recorded. Other months showed resting was lowest when feeding was highest. Although behavioural events varied over the study period, seasonal variations were only significantly different in resting and travelling, in spite of the fact that they showed much active feeding during the wet season. Seasonal change in resources within the mangrove habitat suggests a reason for these variations to happen. In other primate studies, seasonal change in habitat resources affected primate ranging behaviour (Dela, 2007; Grueter et al., 2009; Takemoto, 2004). In addition, phenological trends in mangrove forest may explain the difference in both monthly and seasonally behavioural events as described in Chapter 6. In Australia, Papua New Guinea and New Zealand, both monthly and seasonal changes in habitat resources affected phenology trends in mangrove species, especially *Avicennia marina* (Duke, 1990) and other species including *Sonneratia alba* (Coupland et al., 2005). Therefore, as mangrove species varied in phenology trends according to species, seasonal variation in mangrove species may also have some effects on routine activity of Proboscis Monkey in this study.

Comparison of two study sites

This study was the first of its kind to examine tree and ground activities of Proboscis Monkey in two different habitats. Proboscis Monkey most frequently engaged in daily activity within the confines of trees in heath forests in Bako National Park, and mangrove forests in Kuching Wetland National Park. Tree activity in Bako National Park was lower (89%) as opposed to Kuching Wetland National Park (99%). As Proboscis Monkey is arboreal primate (Bennett & Davies, 1994; Galdikas, 1985; Napier & Napier, 1967; Yeager, 1991b), it spends most of its behavioural routine in trees (Bennett & Gombek, 1993). The Proboscis Monkey's habitat in Bako National Park is more diverse than that of Kuching Wetland

National Park, and the heath and mangrove forests in Bako National Park therefore provide more choices for the monkeys engaging in their daily routine. However, due to the lack of canopy connectivity in Bako National Park, they need to travel across open spaces at the interface of heath and mangrove forests, which contribute to higher frequency of ground activity compared to Kuching Wetland National Park. Ground activity is not a preferred choice for Proboscis Monkey at either study site since the trees offer increased safety. It is not safe for Proboscis Monkey to engage in ground activity, especially in Kuching Wetland National Park, due to the presence of estuarine crocodile. In Kalimantan, Indonesia, crocodile, false gavial (*Tomistoma schlegelii*) was the main predator (Galdikas, 1985). However, there was no observed incidence of the study group being attacked by predators, although on a number of occasions estuarine crocodiles were sighted in the area.

Forest structure in heath forests in Bako National Park is composed of various types of stands, as opposed to mangrove forests in Kuching Wetland National Park. Proboscis Monkey can access a variety of resources in both heath and mangrove forests in Bako National Park. In addition, there are good stands and connectivity for tree activity in heath forests accessible to Proboscis Monkey. The availability of resources in trees meant that Proboscis Monkey has wide choice in relation to their behavioural routine. Distribution of resources in the canopy may contribute to the importance of tree activity to Proboscis Monkey. Some primates

(Putty-nosed Monkeys and Spectral Tarsiers) perform different activities at different height of trees (Bitty & McGraw, 2007; MacKinnon & MacKinnon, 1980). Previous studies reported that arboreal activities of Proboscis Monkey most frequently occurred in the top level of canopy height of between 20 – 21 m (Boonratana, 1993) and 20 – 30 m (Ginting, 2009). Although tree height influenced ranging behaviour of Proboscis Monkey (Boonratana, 2000), the affects of forest strata on behavioural routine of Proboscis Monkey were not extensively researched. In this study behavioural activity also occurred most frequently in the top level of canopy or the upper canopy (1^{st} stratum) (39%) as opposed to middle canopy (2^{nd} stratum) (38%) and above the ground (3^{rd} stratum) (23%). Proboscis Monkey mostly preferred upper canopy in performing routine activity because this stratum may have some preferred resources and useful structure to perform the relevant activity routines. Tropical rain forest provides abundant resources for folivorous primates (Harris et al., 2010; Isbell, 1991) and these resources are ever-present in the upper canopy of tropical forests (Hladik, 1978a). Behavioural routines showed variation by month of study period according to forest strata, with routine behaviour occurring most frequently in the upper canopy in December (50%), in the middle canopy in November (50%) and February (50%), and above ground in September (42%). This variation may be related to the production of resources which are localized and available at different months in the year according to species (Hemingway & Bynum, 2005; Hladik, 1978b; Medway, 1972; Wright & Schaik, 1994). Variation in behavioural routine was also evident between the dry and the wet season with most frequently occurred in upper canopy. As tropical rain forests have drought-sensitive and drought-tolerant species (Wright & Schaik, 1994), resources that are preferred by folivorous primates may be available in both dry and wet seasons.

Habitat types also have an influence on activity routines, judging from the varied frequency of behavioural activity occurring among the habitat types in this study. In other primate research, habitat types were reported to have influenced routine activity (Barton et al., 1992). In this study Proboscis Monkey mostly preferred H1 (medium closed heath forest) and was most active in July and November. Behavioural events occurred most frequently during the wet season in H1 (medium closed heath forest) and the dry season in H3 (coastal mangrove). H1 has a diverse structure of forests and good connectivity, as well as varied choices of resources for activity routines. Besides having a quality habitat structure for Proboscis Monkey, H1 is also composed of a few food plants preferred by the monkeys. H3 is a single type of habitat which is dominated by mangrove forests. Mangrove forests at Teluk Assam (Bako National Park) in H3 were the preferred habitat for the monkeys because almost every day they were found to be engaged in activity routines in this habitat. However, routine activity was less frequent in these mangrove forests as opposed to heath forests, due partly to factors such as the presence of visitors, high tides, less variety of resources and sleeping sites being located in heath forests. Less variety of resources in mangrove forests was evidenced by the drastic change in forest structure due to the evident die-back of the mangroves.

In contrast, in Kuching Wetland National Park mangrove habitat was clearly the most preferred habitat for Proboscis Monkey, as behavioural activity only occurred in this habitat over the study period. Mangrove habitat provides a range of resources and a suitable venue for the monkeys to engage in routine activity. As the monkeys maintained their group while engaging in routine activity, group activity mostly occurred in one or two trees rather than being sparsely distributed. The availability of resources may explain this behaviour, as routine activity mostly occurred in between Level 1 and Level 2 of tree crowns. Of these canopy levels, Level 2 appeared to be most highly preferred as routine activity mostly occurred in Level 2 in both dry and wet seasons. However, different types of habitat as shown in behavioural polygons affect routine activity of Proboscis Monkey. The concentration of resources is easily found in central polygons. The highest frequency of behavioural routine activity in central polygons indicates that this type of habitat is mostly preferred by Proboscis Monkey. The central polygon is composed of food plants preferred by Proboscis Monkey, and is dominated by *Sonneratia-Avicennia* communities. This also explains why the monkeys did not travel too far from the central polygon, and their sleeping sites are either near or within the central polygon. Mangrove stands in between Sg. Jebong and Sg.

Pergam are spatially distributed and provide some good connectivity for tree activity.

5.5 CONCLUSIONS

This study of the behavioural activity of Proboscis Monkey in two very different study sites has provided a valuable insight into landscape and habitat use and preference, and the behavioural ecology of the species. Based on behavioural activity there appears to be a preferencial use of certain habitat types which may be explained by forest characteristics (structure and composition), environmental variables (tide flow), and/or human activities. In Bako National Park the preferred habitat was heath forest while in Kuching Wetland National Park the monkeys' preference was mangrove forest. While behavioural activity may be less frequent in some habitats, they may nevertheless be critical to the species which may or may not be evident in a behavioural analysis over a 12 month period (e.g., provide refuge, linkage from one area to another, important food source at time of food scarcity, etc).

Summary of key findings:

a. Landscape and Habitat Use and Preference

1. Behavioural activities of Proboscis Monkey occurred in a variety of habitat types including the medium closed heath forest and the coastal mangrove

of Bako National Park, and the riverine mangrove of Kuching Wetland National Park.

2. The type and frequency of these activities varied across different habitat types which may be explained by forest characteristics (structure and composition), environmental variables (tide flow), and/or human activities.
3. Frequency of behavioural activities was highest in habitats that appeared to contain an intact forest structure, essential food plants, and least human or tourist activity.
4. Behavioural activities were higher in upper canopies of heath forests and and upper crown levels of the mangrove forests

b. Behavioural Ecology

1. Frequency of feeding was higher compared to other behavioural activities in both study sites.
2. Frequency of feeding was higher in Kuching Wetland National Park compared to Bako National Park partly due to abundance of the preferred food resources, especially *Sonneratia alba* in Kuching Wetland National Park.
3. Male Proboscis Monkey engaged in more feeding than female Proboscis Monkey in both study sites. In contrast, female Proboscis Monkey engaged more in resting than male Proboscis Monkey.

4. Monthly behavioural activities varied especially feeding, resting and travelling events. The variation between the highest and the lowest months these events were performed was significant different in both study sites.
5. Seasonal change between wet and dry seasons affected feeding, travelling and resting in Bako National Park and only affected resting and travelling in Kuching Wetland National Park.

CHAPTER 6 FORAGING BEHAVIOUR AND DIET

6.1 INTRODUCTION

Previous studies on feeding ecology of Proboscis Monkey mainly focused on one habitat type and comparisons between two or more similar habitats in different locations (Matsuda et al., 2009a; Yeager, 1989a). While valuable information has been provided with these studies, a more comprehensive understanding of feeding ecology is still lacking. This is because Proboscis Monkey's diet in the wild is more varied than has previously been understood and the phenology of some food plants does not follow mass flowering and fruiting of many tropical rain forests. In addition some food plants foliate regularly and are available during all seasons (Hon & Gumal, 2004; Matsuda et al., 2009a; Yeager, 1989a).

Proboscis Monkey belongs to the Old World group called colobines. Colobines have the most enormous stomach (Bennett & Gombek, 1993) which is divided into the *saccus gastricus,* with or without a *presaccus* – both sites of bacterial fermentation, and the *tubus gastricus* and *pars pyloric* in which enzymatic digestion is initiated (Nijboer & Clauss, 2006). Colobines' stomach contain huge numbers of bacteria within a liquid that allows them to digest food to obtain energy (Bennett & Gombek, 1993). Although most colobines exclusively consume leaves, fruits and seeds (Nijboer & Clauss, 2006), Proboscis Monkey was found to be more varied in their diet (Bennett & Sebastian, 1988; Matsuda, 2008; Matsuda et al., 2009a; Salter & MacKenzie, 1981), with young leaves forming a significant proportion of this diet (Matsuda, 2008; Yeager, 1989a). They also showed variation in terms of amount of food items consumed (Bennett & Sebastian, 1988; Matsuda, 2008) depending on their size, age and gender and daily activities they performed (Bismark, 2010). However, colobines' specialized stomachs and adaptations for living in forests and on the food resources available in these habitats and the very selective nature of food items they consume mean they do not do well in more open, or human-made environments compared to cercopithecines (Bennett & Gombek, 1993). Most of the food eaten by Proboscis Monkey is digestible food but bitter, and non-sugary and not sweet fruit (Bennett & Gombek, 1993).

Plant species categorized as food plants for Proboscis Monkey also varied according to habitat and locations. In riverine forests along the Menanggul River, Sabah, a total of 127 genera of 55 families and among these, young leaves, fruits, and flowers of *Eugenia* sp. (*Syzygium* sp.), was frequently consumed by Proboscis Monkey (Matsuda et al., 2009a). In the peat swamp forests in Sekonyer Kiri river, Tanjung Putting National Park, Indonesia, Proboscis Monkey used 55 plant species of 19 families as food sources and among these *Eugenia* sp. (*Syzygium* sp.) was their most preferred (Yeager, 1989a). Additionally, in Tanjung Putting National Park, 30 families of plant species were used for their leaves, mostly young leaves, and 17 species for their fruit, seed and flower (Yeager, 1989a). In seven locations in Sarawak, Proboscis Monkey was found feeding on at least 90 different species of plants in 39 families and the species mostly eaten were from the families of Dipterocarpaceae, Rhizophoraceae and Sapotaceae. Of these 90 species, 75 species were utilized by Proboscis Monkey for their leaves and shoots including 15 species for their fruits, 10 species for their seeds and 4 species for their flowers (Salter & MacKenzie, 1981; Salter et al., 1985). Although young leaves were the most preferred food, fruits and seeds formed over half of Proboscis Monkey's diet in Samunsam Wildlife Sanctuary (Bennett & Sebastian, 1988). The seeds favoured by Proboscis Monkey were mostly from the families of Leguminosae (Fabaceae) and Myristicaceae (Bennett & Sebastian, 1988).

Dietary switching among primates (Berry, Dawson, Harrison, & Pearson, 2002; Harris et al., 2010; van Schaik et al., 1993) is one of a number of responses to food scarcity as a result of phenological patterns (Hemingway & Bynum, 2005). Primates obviously change their diet when there is extreme seasonal change in food availability. During low production of key food items, primates switch and consume more of other less preferred food items in addition to eating whatever key food items are available (Harris et al., 2010). Tropical forest provides ever-present and abundant leaves for folivorous primates (Harris et al., 2010; Isbell, 1991; Wrangham, 1980). Relatively little feeding competition exists among the folivorous primates because in certain circumstances Snaith and Chapman (2007) suggested that there may be food-limited available for folivorous primates as opposed to other primates. Habitat types will influence primate foraging behaviour because of the availability of different types of food plants. Habitats that incur human disturbance were reported to influence wildlife species diversity, densities and distribution (Gandiwa, 2011). Thus in this study, I compare foraging behaviour of Proboscis Monkey in two different types of habitat using the same technique of observation. Specifically, the preferred objective and sub-objectives of this study are:

1. To investigate if seasonal change in habitat attributes influences the foraging behaviour of Proboscis Monkey by

    1.1 examining whether seasonal fruiting and flowering changes foraging behaviour; and

    1.2 documenting the preferred food plants and food items of Proboscis Monkey and seasonal variations in this preference.

6.2 METHODS

6.2.1 Diet and Behaviour Observations

During the day of observation, in addition to recording each behavioural event over the five-minute-sample period (as described in Chapter 5), and the intervening 30 minute incidental observation period, all food plants eaten by Proboscis Monkey was identified on the spot after it left the feeding area. This was undertaken with the assistance of the second field observer. Food plants that could not be identified were marked with ribbon tapes, photographed and samples were collected. Samples of food plants were taken to the Forest Botany Section of Forest Department Sarawak and were identified using the collection of Forest Herbarium. A Vivitar Series1 Binocular 7x35WA was used to observe feeding behaviour and types of food plants the monkey ate. In this way the diet of study animals was established.

Feeding bouts were recorded when they plucked and put the food item into their mouth for a continuous period without interruptions. Counts were made of the rate of ingestion when individual animal could be seen handle food items (Chapman, 1988a).

Bearing location of the animals and distance from the observer was measured by Suunto KB-14 compass and Leica laser distance measurement. In the inaccessible landscape matrix (Lindenmayer, Cunningham, MacGregor, Tribolet, & Donnelly, 2001), especially on the cliffs I used Suunto KB-14 compass to measure the distance (Bruce & Schumacher, 1942). I took two bearings from both end of fixed distance that perpendicular to the monkey position and applied trigonometry-tangent concept (Haris & Stocker, 1998) for this exercise. In Bako National Park, the foot survey was conducted at Teluk Assam-Paku Trail-Lintang Trail zones. Whereas in Kuching Wetland National Park, the survey was carried out by boat and foot during high and low tide in between Sg. Pergam and Sg. Jebong area. Only on a number of occasions was the foot survey able to be conducted due to presence of crocodiles.

6.2.2 Vegetation Sampling

In Bako National Park, I with one field assistant and one casual labourer made five sampling quadrats along Paku Trail-Lintang Trail zones in the heath forest. The size of each sampling quadrat was 20 m x 20 m and located 5 m away from the trail. The distance between each quadrat was not less than 100 m depending on the terrain. All trees ≥ 10 cm D.B.H. were measured and tagged. The total height of trees was calculated using trigonometric principle (Figure 6.1). For this exercise, I took two angles that I shot using Suunto clinometers from the base of the tree stem and the topmost tip of the tree (Köhl, Magnussen, & Marchetti, 2006). The horizontal distance from my position on the ground to the tree was measured using measuring tape. However, when I stood on the same contour with the tree, I took only one angle from the topmost tip of the tree to some reference fixed on the stem that was in horizontal distance from my eyes (Kanowski et al., 2010). The height of myself above the base of the tree and the distance between the tree and I were measured. A total of 132 trees ≥ 10 cm D.B.H. were censused and broken down into different D.B.H classes (Table 6.1).

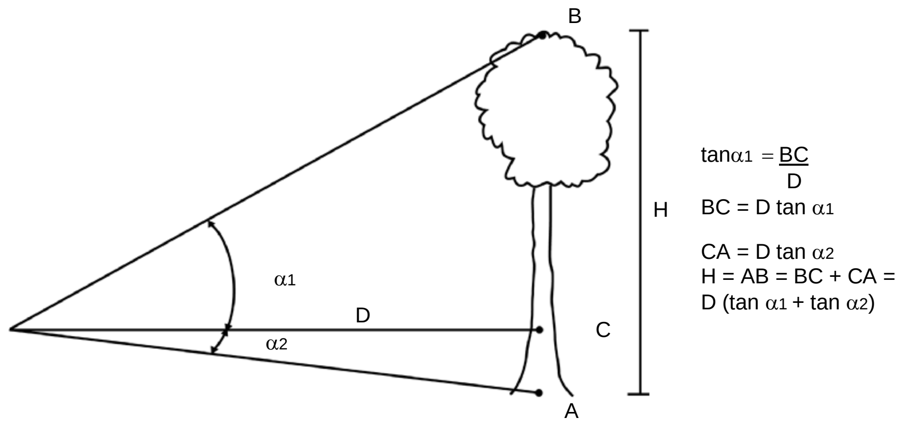


Figure 6.1: Height measurements: trigonometric principle
(Source: Kohl et al.(2010))

Table 6.1: Number of tree in phenology quadrats at Bako National Park

Quadrat	Trees in D.B.H. classes							No. of tree in quadrat
	I	II	III	IV	V	VI	VII	
Q1	12	4	2		1			19
Q2	13	4	3	2	2	1		25
Q3	9	12	6	6	1			34
Q4	16	12	2	1	1	2	1	35
Q5	6	5	5	3				19
Total								132

D.B.H. class: I, ≥ 10 cm < 15 cm; II, ≥ 15 cm < 20 cm; III, ≥ 20 cm < 25 cm; IV, ≥ 25 cm < 30 cm; V, ≥ 30 cm < 35 cm; VI, ≥ 35 cm < 40 cm; VII, ≥ 40 cm

These quadrats were visited once a week from June 2011 till May 2012. Flowering and fruiting trees were recorded. Certain food plants eaten by Proboscis Monkey were tagged and photos were taken every week to find out percentage of young leaves, flowers and fruits. I used Nikon D90 digital camera mounted with 18-200 mm lens. I set up the shooting mode to natural (N) to produce a photo as natural as possible with minimizing artificial colour effect. I marked my position on the ground with a stick perpendicular to each food plant such that I maintained my distance from the tree every week I took a photo. Each digital image was imported into Microsoft Word. A 10 x 10 grid drawn in Microsoft Word was superimposed over the digital image. The number of grid intersections with young leaves, flowers, and fruits were counted to estimate their respective percentage (Kanowski et al., 2010).

6.2.3 Mangrove Phenology Plot

In the mangrove forests in Bako National Park, 3 plots comprising of 5 quadrats each were set up in the small pocket of mangrove in parallel with the coastal line. The distance between each plot was not less than 100 m and distance between each quadrat was 50 m. Each quadrat size was 20 m x 20 m. In Kuching Wetland National Park, a total of 5 plots comprising of 5 quadrats each of the same size were established, and also parallel with the coastal line. All trees ≥ 10 cm D.B.H. and their height were measured (Table 6.2).

Table 6.2: Mangrove species ≥ 10 cm D.B.H. in phenology plot at both study sites

Plot	Distribution of mangrove species in each plot (per cent)													
	Bako National Park							Kuching Wetland National Park						
	I	II	III	IV	V	VI	No. of tree	I	II	III	IV	V	VI	No. of tree
P1		28.6	20.4	36.7		14.3	49	18.2	69.1		1.8	10.9		55
P2	99.0		1.0				84	92.5	7.5					53
P3	90.1	2.5	2.5	4.9			81	94.1	5.9					51
P4								92.3	7.7					39
P5								96.9	3.1					32
Total							214							230

Species: I, *Sonneratia alba*; II, *Avicennia alba*; III, *Avicennia marina*; IV, *Rhizophora apiculata*; V, *Rhizophora mucronata*; VI, *Bruguiera*spp.

With the help of a field assistant, phenology of mangrove forests was undertaken every week at both study sites. Young leaves, flowers, flower-buds and fruits were counted in one crown unit and multiplied by the number of crown units in the tree (Kavanagh, 1987). For this purpose, 5 trees were selected in different positions in each quadrat and tagged from T1 to T5 (Figure 6.2). The ribbon tag was always replaced with the new one to ensure it kept intact as the area was inundated by high tide.

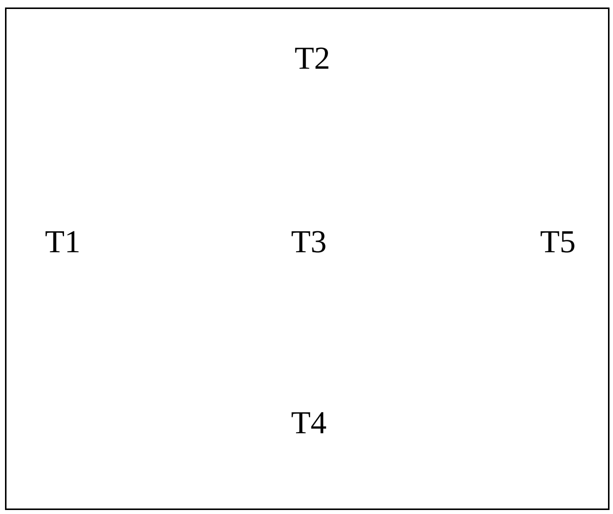


Figure 6.2: Diagrammatic positions of selected trees in quadrat

6.2.4 Data Analysis

Monthly Food Category Variation Data from twelve hourly observations a day (from 6:30 am to 6:30 pm) combined into monthly records was used to analyse monthly feeding according to food categories. The non-parametric Mann-Whitney U-test for two independent samples was used to test for significant differences between the highest and the lowest feeding months. The chi-square test of independence factors was used to test for significant differences between feeding on food items and months. P-values of 0.05 or less were considered significant.

Seasonal Food Category Variation I used data of twelve hourly observations to analyze feeding on food items across the wet and the dry seasons. The non-parametric Mann-Whitney U-test for two independent samples was used to test for significant differences between wet and dry seasons. The chi-square test of independence factors was also used. P-values of 0.05 or less were considered significant.

Relationship between Food Item Intake and Feeding Frequency Data from twelve hourly observations a day was used to analyse frequency of feeding and food items-feeding (food intake) in Bako National Park and Kuching Wetland National Park. The relationship between frequency of feeding and food items-feeding was further investigated using Spearman Rank Order Correlation (rho).

Plants Phenology and Food Seasonality The chi-square test of independence of factors was used to test for significant differences between phenology of plants (foliating, flowering and fruiting events) and months over the study period. The non-parametric Mann-Whitney U-test for two independent samples was also used to test phenology of plants between the wet and the dry seasons. P-values of 0.05 or less were considered significant.

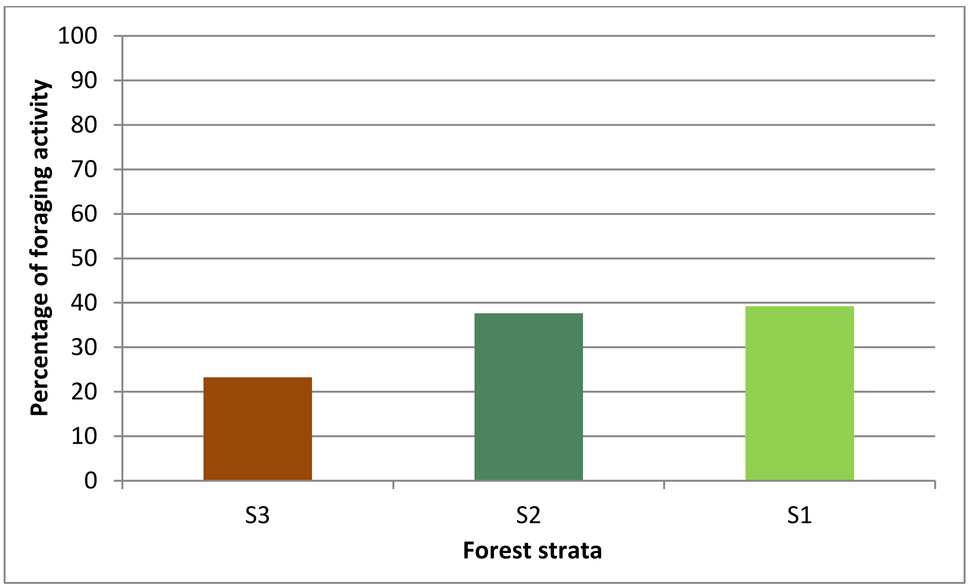
Relationship between Plant Phenology and Feeding The relationship between frequency of feeding and phenology of plants was further investigated using Spearman Rank Order Correlation (rho). This analysis used data of twelve hourly observations combined into monthly records of feeding frequency and monthly phenology of plants (foliating, flowering and fruiting events) in Bako National Park and Kuching Wetland National Park.

6.3 RESULTS

6.3.1 Foraging Techniques

a. Bako National Park

Over the period of field work, from June 2011 to May 2012, this study group of Proboscis Monkey spent most of their daily foraging activity within the confines of trees (88%) as opposed to foraging on the ground (12%). On rare occasions they would venture down to the forest floor. This was mainly associated with the need to travel across open spaces at the interface of heath and mangrove forests due to a lack of canopy connectivity rather than ground foraging and drinking. Nevertheless, as described later, juveniles would come down to the ground specifically to feed on seedlings. Foraging in trees was further categorised according to three forest strata. Analysis for tree foraging in these different strata was based on a nine-month-observation period as data for other months were inadequately categorised. Tree foraging most frequently occurred in the first (S1 - upper canopy, 39.1 per cent) and second (S2 - middle canopy, 37.6 per cent) strata of the forests (Figure 6.3). The remaining 23.2 per cent occurred in the third stratum, the undergrowth or understory layer but above the ground (S3).



S1-1st Stratum, S2-2nd Stratum, S3-3rd Stratum

Figure 6.3: Foraging activity in different forest stratums

Ground foraging involving juveniles occurred both in heath and mangrove forests. However, details of this behaviour in heath forests were difficult to record due to thickets, rugged rocks, and/or palm fronds obstructing a continuous view of the study animals. Other age groups of Proboscis Monkey were rarely found engaged in ground activity in heath forests. Conversely, ground activity in mangrove forests involved all age groups.

Foraging Path Foraging habitat options available to this study group of Proboscis Monkey constitutes both mangrove and heath forests. However, over the period of study they did not forage every day in mangrove forests. Nevertheless, the daily foraging routine followed a similar pattern. The foraging paths that formalised these patterns changed slightly every day. This pattern formed either a closed or open traverse which I called 'foraging polygon'. Daily 'foraging routes' or feeder paths within the foraging polygon were mostly similar. Similar daily foraging routes were also used to traverse from heath to mangrove forests. This suggested a familiarity with the landscape and knowledge of where the food plants were. So their feeding movements were mostly confined in the areas in Teluk Assam-Paku Trail-Lintang Trail zones.

Foraging paths traversed habitat to habitat, canopy to canopy, tree to tree, and sometimes across the open forest floor. The study group needed to cross open ground when the tree crown connectivity was not enough for them to jump across. Average horizontal jumping distance (HJD) from one branch to another was 2.3 m for the adult and 1.5 m for the juvenile. They always jumped in a forward motion but at an angle of less than 45 degree from a higher branch of a tree to the lower branch of the next tree. On a number of occasions, they would swing at least three times before jumping from one crown to another crown.

Foraging in Mangrove Forest Fifty-four 12 hourly observations (648 hours) of this study group of Proboscis Monkey revealed that they most often came to the mangrove forest once daily between 6:30 am and 9:30 am (70.4%) (Table 6.3). On six of the 12-hour-observation periods they did not come to this forest at all.

Table 6.3: Frequency of foraging in mangrove forests

Foraging in mangrove	Observations
Absence	6
Once daily	38
Twice daily or more	10
Total	54

Occasionally their stay in this forest lasted till 11:00 am. Seven per cent frequency of daily foraging activity occurred in mangrove whenever the monkey foraged once daily in these forests, and more than 15 per cent frequency of daily foraging activity when foraging twice daily in the mangrove forests. Their foraging activities were sometimes interrupted due to the presence of tourists walking, photographing, and watching them from the boardwalk. This will be discussed in more detail in chapter seven. If there were no interruptions they would come to the mangrove forest twice daily between 6:30 am and 6:00 pm during low tides (18.5%). However, this study group of Proboscis Monkey was also observed foraging in the mangrove forests on three occasions during high tides from 6:30 am to 6:00 pm when there were no tourists present.

Strategies Used for Obtaining Food During tree foraging, this study group of Proboscis Monkey mostly used their hands to pick a food item from its source, as opposed to using their mouths to directly pick or collect the item. Hand picking foraging bouts for an adult male Proboscis Monkey occurred at a rate of between 20 and 25 picks per minute. For juveniles this occurred at the slower rate of 12 and 15 picks per minute. A feeding bout would be predicted to occur at a much slower rate if selecting and other foraging activities were accounted for.

Quite often this study group of Proboscis Monkey used their right hand for plucking and putting food plants, especially young leaves, into their mouth. When eating young leaves, they sometimes would put more than one single leaf or leaflet in their mouth (Figure 6.4). On other occasions they would grab a bunch of leaves and hold them before eating. They ate from the leaf-tip and sometimes threw away the leaf-base. Occasionally, they used their mouth to directly access the still attached food item but supported this using their hand to move the twigs close to the mouth. This accounted for less than one per cent of the total number of incidental observations made.

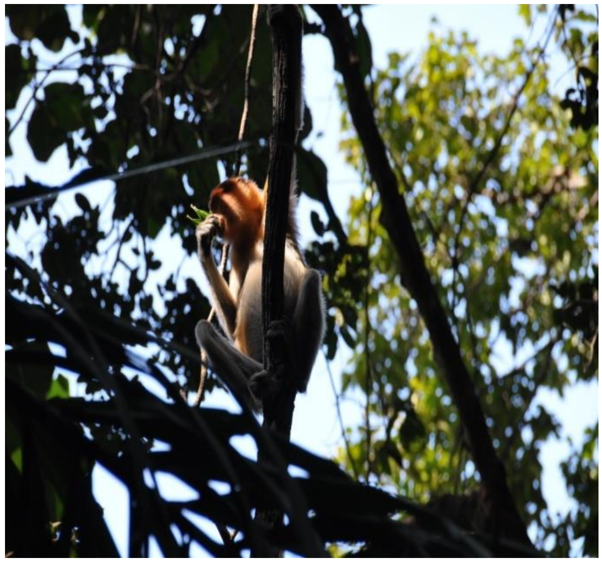


Figure 6.4: Proboscis Monkey eating more than one leaf from the leaves-tips

Food Selectivity During continuous feeding bouts food selectivity, that is choosing food items on the basis of colour, softness, odour, taste, inspecting the food item, etc, did not appear to occur amongst the adults of the study group. On the other hand juveniles appeared to be very selective in choosing plants to be eaten; often testing a number of plant leaves, especially young leaves and shoots, before consuming them. Juveniles foraged alone, detached from the main group, often at a horizontal distance of more than 15 m away, making them very evident as a separate age group. On a number of occasions I observed juvenile Proboscis Monkey engaged for long periods of time in this process of food selectivity. On a number of occasions I observed a juvenile descending to the forest floor looking for some seedlings of food plants. It proceeded to pluck the plant leaf, put it into its mouth, but then spat it out again. On another occasion a juvenile plucked a leaf off the seedling, smelled it and then threw it away. In November and December 2011, a juvenile was observed testing the base of the leaves of *Pandanus odoratissimus*. Apparently satisfied, it continued to dig deeper, clearing away plant material in the search for more. In this process the juvenile Proboscis Monkey consumed the base of the leaves directly using its mouth. It spent almost half an hour eating the leaf bases of *Pandanus odoratissimus* before joining the main group, which was now separated 20 m away in horizontal distance and located on *Syzygium* sp.

As evident in Figure 6.5, the juvenile engages in carefully selecting young leaves of *Mesua calophylloides,* spending 15 minutes in this process. This occurred in the fourth week of March 2012. In November 2011, I observed juveniles eating some seeds of *Myristica lowiana*. On a number of occasions the juvenile picked up one fruit and peeled the mace off this nutmeg fruit with its teeth, then threw it away. But the same juvenile picked up another fruit from the same *Myristica lowiana* tree, peeled the mace off and then ate the seed.

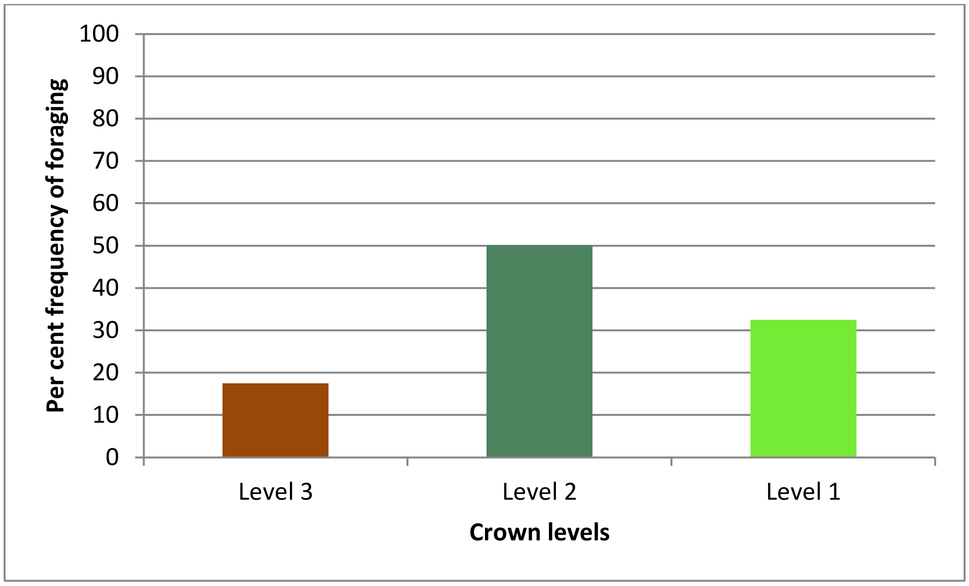
Figure 6.5: A female juvenile Proboscis Monkey selecting young leaves

Only on one occasion I observed a lactating adult female throwing away the mace of *Myristica lowiana* after she had peeled it off using her teeth. She plucked the fruit with both hands; her baby clung under her belly on the right side. During eating the seed, the lactating female used both hands to bring the fruit to its mouth. When actually eating, its left hand was used to support its baby. The adult male was never observed throwing the fruits it took without eating the seeds. It spent at least 10 minutes sitting and eating in the *Myristica lowiana* tree. However, it shifted from one branch to another branch to find suitable fruit to feed on. In January 2012, this study group of Proboscis Monkey was observed eating some fruits of *Palaquium rufolanigerum*. They spent half an hour eating and resting in this tree. Some of the seeds were all eaten but a few only half eaten. They did not eat the pericarps of the fruits (Figure 6.6). However, I did not observe the lactating female eating fruits or seeds of this tree.

Figure 6.6: Fruits of *Palaquium rufolanigerum*

b. Kuching Wetland National

Over the period of field work, from June 2011 to May 2012, this study group of Proboscis Monkey spent most of their daily foraging activity within the confines of trees. On rare occasions they would come down to the ground. Thirty-eight systematic behavioural observations revealed that 99.1 per cent foraging activity occurred in tree and 0.9 per cent on the ground. Foraging in trees was further classified into three categories of crown levels. Analysis for tree foraging in these different crown levels was based on a nine-month-observation period as data for other months were insufficient. Tree foraging most frequently occurred within Level 1 (Top Level Crown) and Level 2 (Middle Level Crown) of the tree crowns which accounted for 32.5 per cent and 50 per cent (Figure 6.7). The remaining 17.5 per cent occurred in the Level 3 (Bottom Level Crown).



Level 1 – Top Level Crown, Level 2 – Middle Level Crown, Level 3 – Bottom Level Crown

Figure 6.7: Foraging at different crown levels

Foraging Path Foraging habitat of this study group of Proboscis Monkey was within the confines of mangrove forests in between Sg. Jebong and Sg. Pergam. Daily foraging path stretched in coastal forest strip dominated by *Sonneratia* communities. Daily foraging routine followed a similar pattern and this pattern changed slightly every day but was most often from southeast to northwest and from south to north directions. Foraging paths that formalised this pattern formed either a closed or open traverse inside the foraging polygons.

Foraging path traversed from canopy to canopy in horizontal direction and rarely occurred in vertical direction. As the forest strata were not evident, single layered habitat canopy mostly provided good connectivity. This canopy architecture facilitated arboreal movements which in turn benefited the daily foraging of this study group as they did not need to incur much travel cost. However, jumping from one crown to another was the normal procedure that this study group followed when searching for food. Consequently, broken branches with less than 5 cm D.B.H. were evident along the foraging paths.

Strategies Used for Obtaining Food Obtaining food with the hand was a common technique used by this study group of Proboscis Monkey in Kuching Wetland National Park. Feeding bouts associated with hand picking the food item were between 20 and 25 bouts per minute for the adult male. An adult female's feeding bout was between 19 and 23 bouts per minute whereas a juvenile was between 12 and 15 bouts per minute. Only occasionally did this study group use its mouth directly, which was normally done by an adult Proboscis Monkey, especially male and occasionally done by a female Proboscis Monkey. It happened when it pulled a small twig in front to its mouth. But on many occasions an adult Proboscis Monkey was found scanning the leaves by looking up and down or left and right, before plucking them. A juvenile mostly used its hand because it had to engage so much in food selectivity process.

Food Selectivity Similar to Bako National Park, this study group of Proboscis Monkey foraged and fed as a group although the juvenile on a number of occasions was found more than 15 m away from the group. Food selectivity was rarely observed which may have been due to feeding predominantly on *Sonneratia* spp. and *Avicenia* spp. However, some selectivity was observed at the river bank where they had to select between young and mature leaves. When feeding on the *Sonneratia* sp. the adult male often positioned itself on lower branches which were strong enough to support its weight especially when engaged in a longer process of feeding and food selectivity.

Food selectivity was most often observed in juveniles. They always lingered between adults and lactating's feeding position and positioned themselves at the height of more than 3 m in the mangrove tree underneath water level during high tide. They spent more than half an hour feeding on a mangrove tree before move to another mangrove tree.

6.3.2 Diet Categories

General Food Intake

a. Bako National park

Proboscis Monkey in this study group did not exclusively utilize a single tree for feeding purposes. Rather a number of trees of the same and varied species were used in their daily forging routine. They were observed eating different consumable food items from 53 species of plants including two vines over the 12-month-study period (Appendix 13). In addition to these plant species, they were also found eating White-rot Fungus (*Lentinus* sp.; on one occasion).

Of the Myrtaceae family, at least nine species provided the food sources most commonly eaten. Among these *Syzygium* spp. was most preferred. From family of Clusiaceae, at least six species provided their most frequently sourced food items, *Garcinia* spp. being their most preferred. These food plants were observed to be foliating consistently. In January 2012, an adult male Proboscis Monkey was observed eating some seeds of *Canthium umbelligerum* (Figure 6.8).

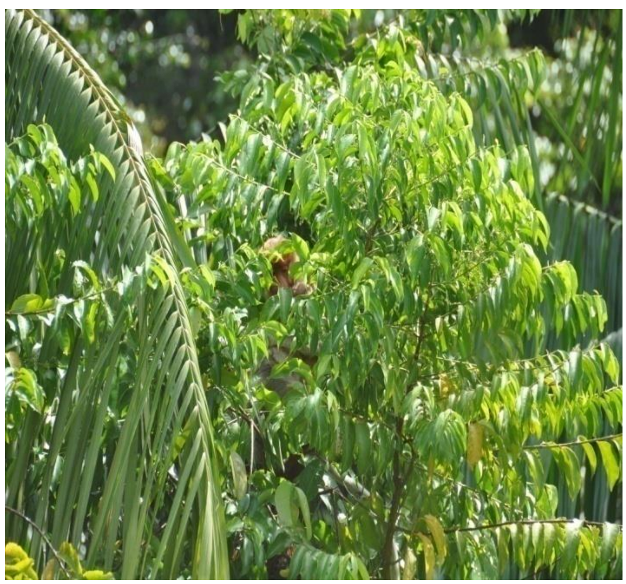


Figure 6.8: An adult male Proboscis Monkey eating seeds of *Canthium umbelligerum*

In January and May 2012, this study group ate some seeds from the fruits of vines. Figure 6.9 shows fruits of vine, *Aidia* sp. where some seeds have been eaten by this study group. In November 2011, on a number of occasions lactating females and juveniles went to the ground searching for food items. They especially searched in between the palm frowns, but it was unclear if they ate crabs or termites. In September 2011, on a number of occasions juveniles went to the ground and ate young leaves of seedlings from *Syzygium* spp. In September and October 2011, they were also found eating seeds from *Syzygium* spp. In mangrove forests, this study group of Proboscis Monkey preferred to eat young leaves of *Sonneratia alba* from the family of Sonneratiaceae.

Figure 6.9: Fruits of *Aidia* sp.

b. Kuching Wetland National Park

Proboscis Monkey in this study group were observed eating different food items from six species of plant from the families of Avicenniaceae, Meliaceae, Rhizophoraceae, and Sonneratiaceae (Appendix 13). They ate most frequently young leaves of *Avicennia alba, Avicennia marina, Rhizophora apiculata, Rhizophora mucronata and Sonneratia alba* for whole study period. The most preferred food plant was *Sonneratia alba,* which foliated consistently over the study period. In January, February, and March, this study group was found eating seeds from the fruits of *Sonneratia alba* (Figure 6.10). However, they were only found eating young leaves of *Xylocarpus granatum* in July, September, October, December 2011 and May 2012 especially the adult females on many occasions ate young leaves of *Xylocarpus granatum* in July and December 2011.

Figure 6.10: Fruiting *Sonneratia alba* in February

Food Category Variation

a. Bako National Park

Per cent Frequency of Feeding According to Food Item Category

This study group of Proboscis Monkey engaged in 55.5 per cent feeding on young leaves (Figure 6.11). Young leaves were found to provide the main source of food. In the heath forest, young leaves from family of Myrtaceae and Clusiaceae were frequently eaten. Shoots were the second preferred food item (33.5%). Many of the plant shoots came from coppices or newly germinated leaves from the trunks, branches, and twigs of food plants.

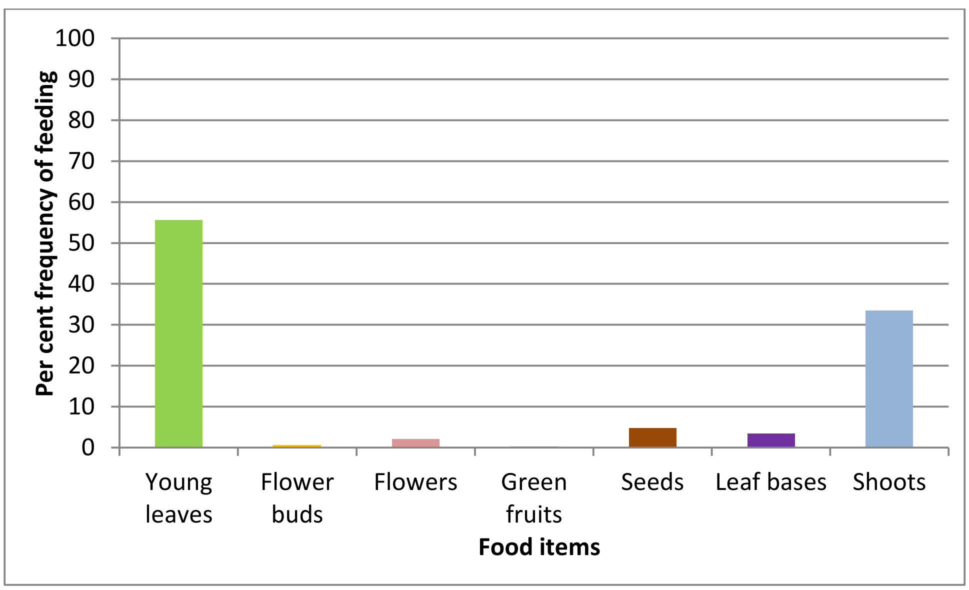


Figure 6.11: Per cent frequency of feeding on food items performed by the combined age category of this study group of Proboscis Monkey in Bako National Park

Other food items included seeds (4.7%), leaf bases (3.4%), flowers (2.1%), flower buds (0.6%) and green fruits (0.2%). They were not recorded eating ripe fruits.

Percent Frequency of Feeding by Age and Gender Category on Food Items

Each age and gender category showed variations in the frequency of feeding events according to food item category.

Adult females The adult females engaged most frequently in feeding on young leaves (48%), and shoots (38.2%), followed by seeds (6.6%), leaf bases (4.1%), and flowers (2.2%) (Figure 6.12). They rarely engaged in feeding on green fruits (0.9%), and did not engage in feeding on flower buds.

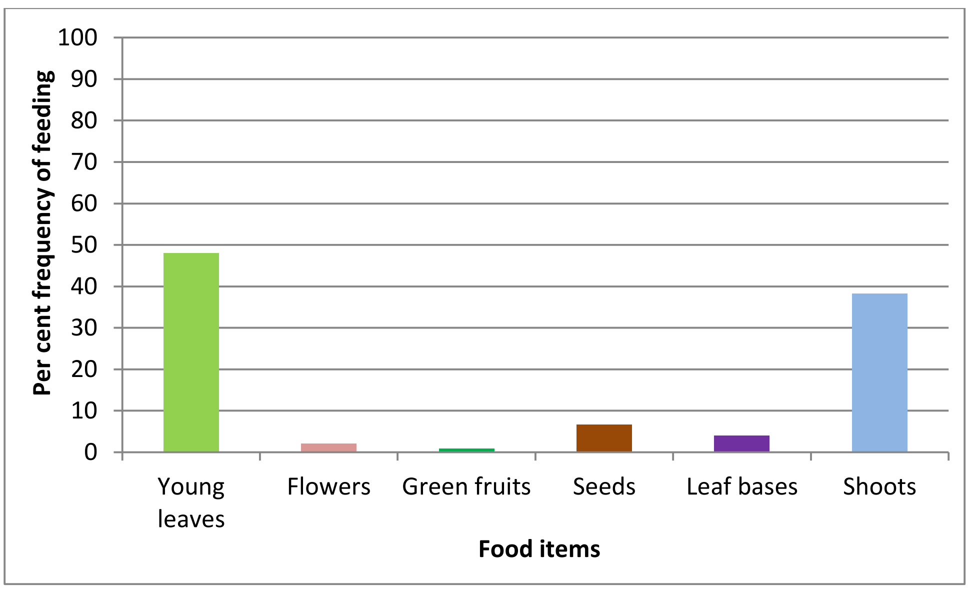


Figure 6.12: Per cent frequency of feeding on food items performed by the adult females of this study group of Proboscis Monkey in Bako National Park

Sub-adult females The sub-adult females engaged most frequently in feeding on shoots (52.9%), followed by feeding on young leaves (30.3%), but similar frequency of feeding on seeds (6.9%) and leaf bases (6.5%) (Figure 6.13). Flower buds (2%) and flowers (1.4%) were the least consumed food items, and they did not consume green fruits.

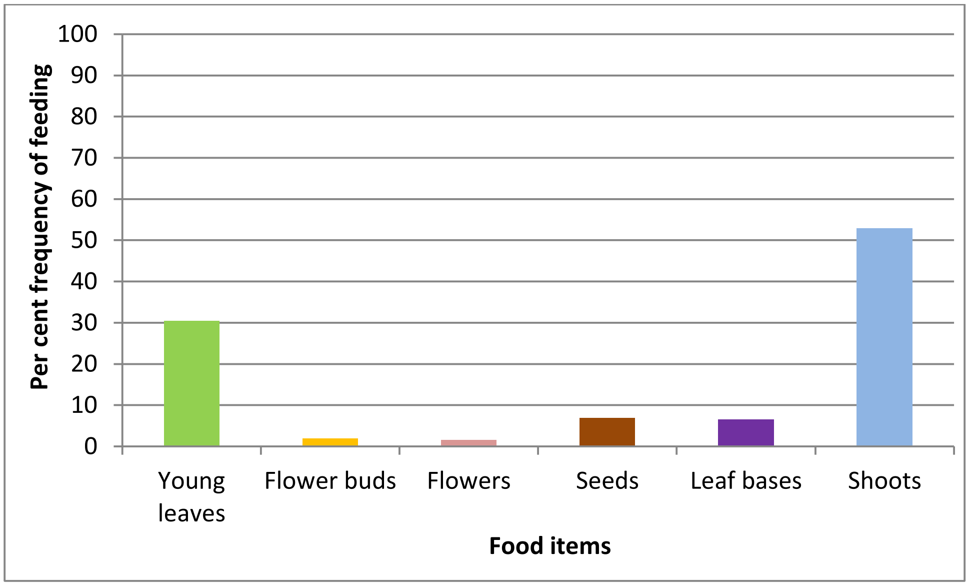


Figure 6.13: Per cent frequency of active feeding on food items performed by the sub-adult females of this study group of Proboscis Monkey in Bako National Park

Adult Male The adult male most frequently consumed young leaves, which at 78.7 per cent is 48.4 percent more frequent than adult females (Figure 6.14). Shoots accounted for 14.3 per cent frequency of feeding events observed. Other food items accounted for seven per cent frequency of its active feeding (seeds 2.7%, flowers 2.1%; leaf bases 1.7%; flower buds 0.5%). It too did not engage in feeding on green fruits.

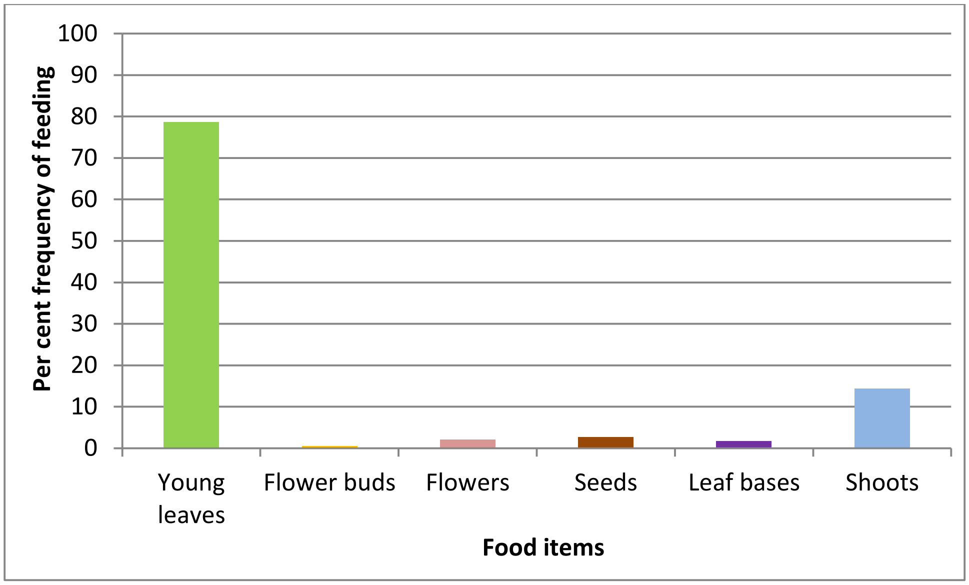


Figure 6.14: Per cent frequency of feeding on food items performed by the adult male of this study group of Proboscis Monkey in Bako National Park

Sub-Adult Males The sub-adult males also engaged most frequently in feeding on young leaves (Figure 6.15), which at a 63.1 per cent frequency rate is 15.6 per cent less than the adult male. However, 22.5 per cent frequency of active feeding was spent consuming shoots (8.2 per cent more frequently than the adult male on the same category of food item). Seeds were the third most frequently favoured food item at 7.4 per cent frequency. Leaf bases accounted for 3.4 per cent frequency of their active feeding, flowers 1.9 per cent, flower buds 0.9 per cent and green fruits 0.8 per cent.

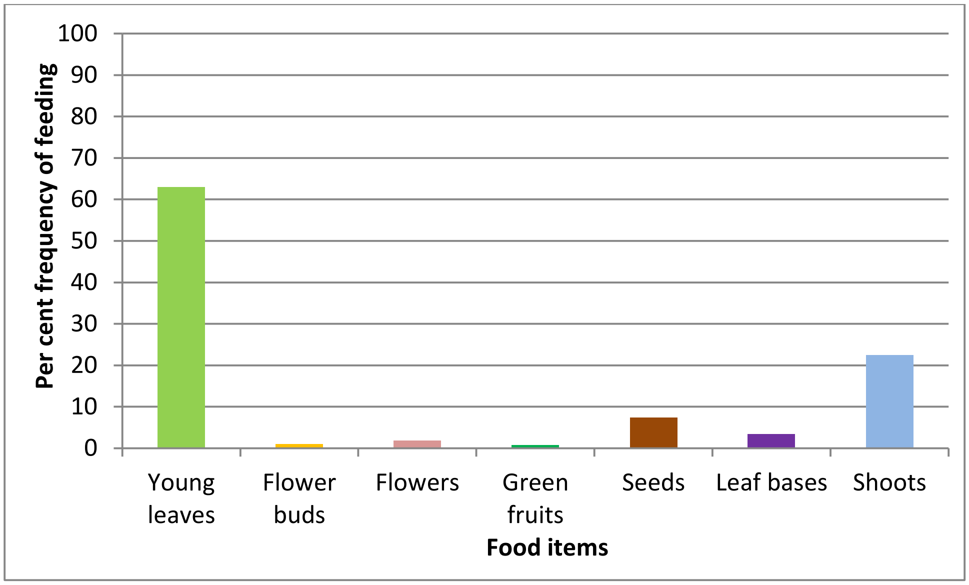


Figure 6.15: Per cent frequency of feeding on food items performed by the sub-adult males of this study group of Proboscis Monkey in Bako National Park

Juveniles The pattern of feeding frequency according to food item category for juveniles was similar to the sub-adult females (Figure 6.16), with 62.4 per cent feeding on shoots. The consumption of young leaves accounted for 25 per cent of their feeding events. Similar to sub-adult females and the adult male, juveniles did not consume green fruits. Leaf bases were 5.5 per cent frequency of their active feeding, seeds 3.9 per cent, flowers 2.8 per cent and flower buds 0.3 per cent.

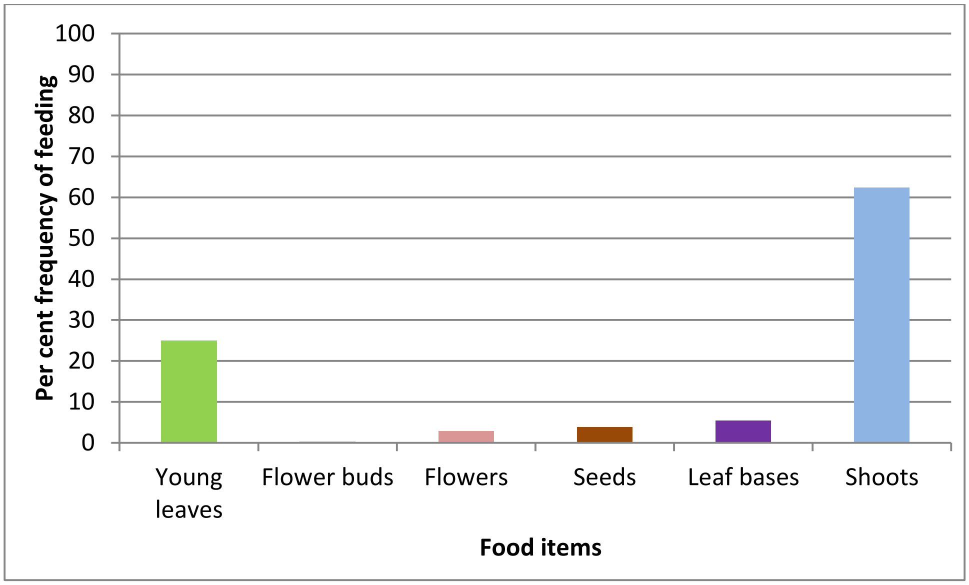


Figure 6.16: Per cent frequency of feeding on food items performed by juveniles of this study group Proboscis Monkey in Bako National Park

Lactating females The lactating females showed a totally different pattern in frequency of active feeding compared to the other age categories (Figure 6.17). They only engaged in feeding on two categories of food items, shoots (91.3 %) and seeds (8.7%).

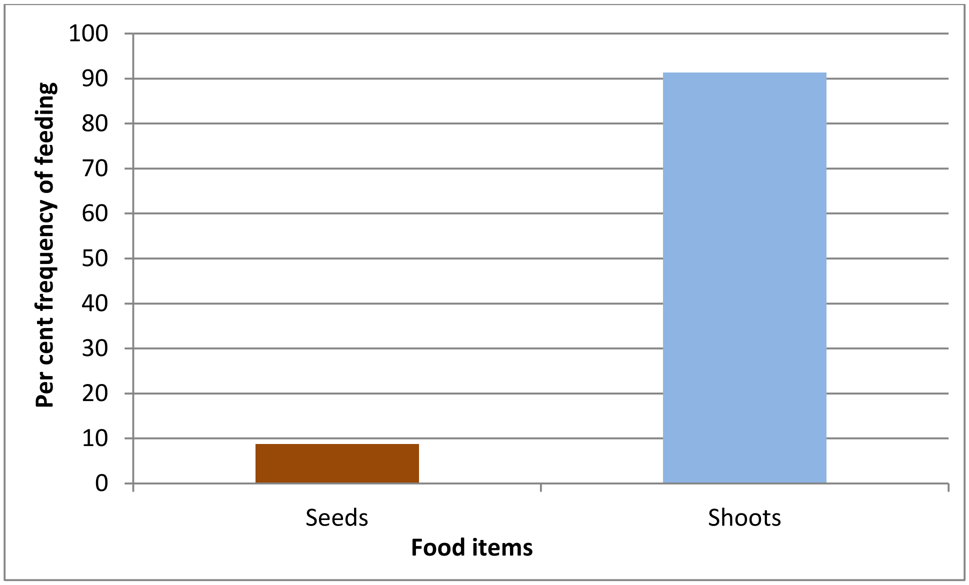


Figure 6.17: Per cent frequency of feeding on food items performed by the lactating females of this study group of Proboscis Monkey in Bako National Park

b. Kuching Wetland National Park

Per cent Frequency of Feeding According to Food Item Category

This study group of Proboscis Monkey showed a slight difference in their feeding pattern compared to the study group in Bako National Park. Of the feeding events observed, 66.1 per cent were focused on young leaves. Shoots were the second preferred food item and accounted for 22.5 per cent of the feeding events (Figure 6.18). Active feeding on seeds was at a 6.1 per cent rate and similar per cent frequency of feeding on green fruits (2.8%) and flower buds (2.6%). Flowers and leaf bases were not eaten.

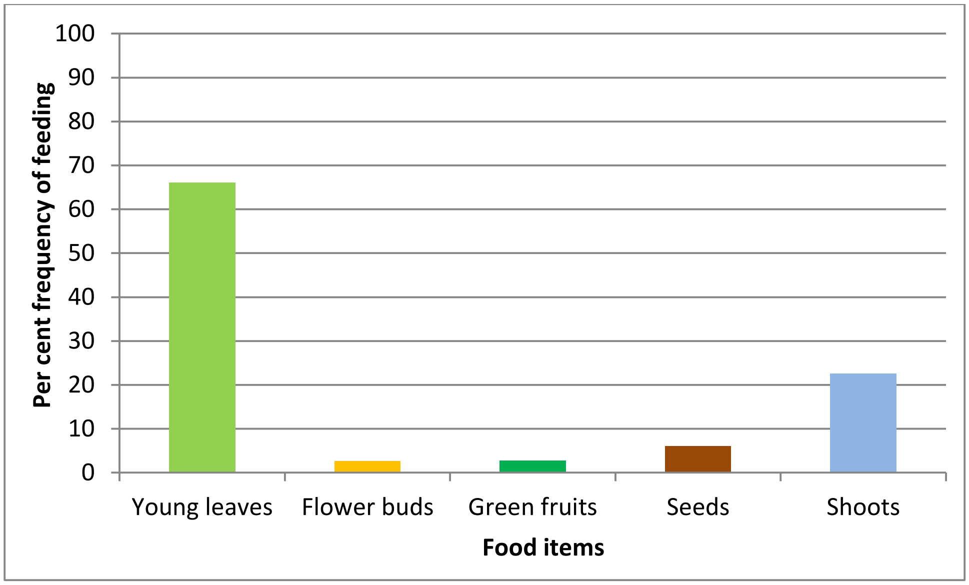


Figure 6.18: Per cent frequency of feeding on food items performed by the combined age category of this study group of Proboscis Monkey in Kuching Wetland National Park

Percent Frequency of Feeding by Age and Gender Category on Food Items

Adult Females Consumption of young leaves accounted for 51.9 per cent of the feeding events observed for the adult females, and shoots 29.4 per cent. They engage in a similar feeding rate on green fruits (6.9%), and seeds (6.3%), but slightly less on flower buds (Figure 6.19).

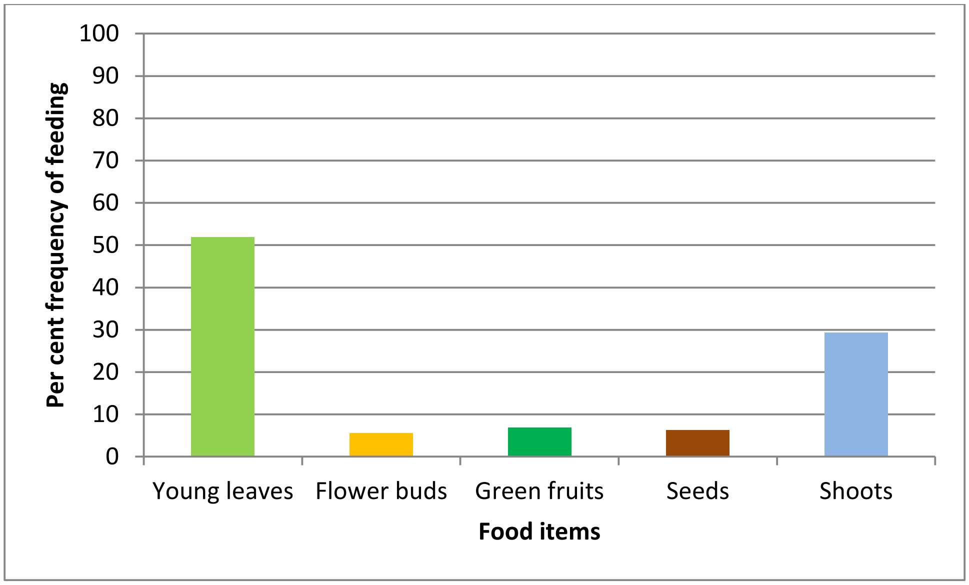


Figure 6.19: Per cent frequency of feeding on food items performed by the adult females of this study group of Proboscis Monkey in Kuching Wetland National Park

Sub-Adult Females Sub-adult females engaged most frequently (44.1%) feeding on young leaves (Figure 6.20), 7.8 per cent less frequently than adult females. They engaged in 40 per cent feeding rate on shoots, 10.4 per cent on seeds, and 4.4 per cent on green fruits. However, they engaged less frequently in feeding on flower buds (1%).

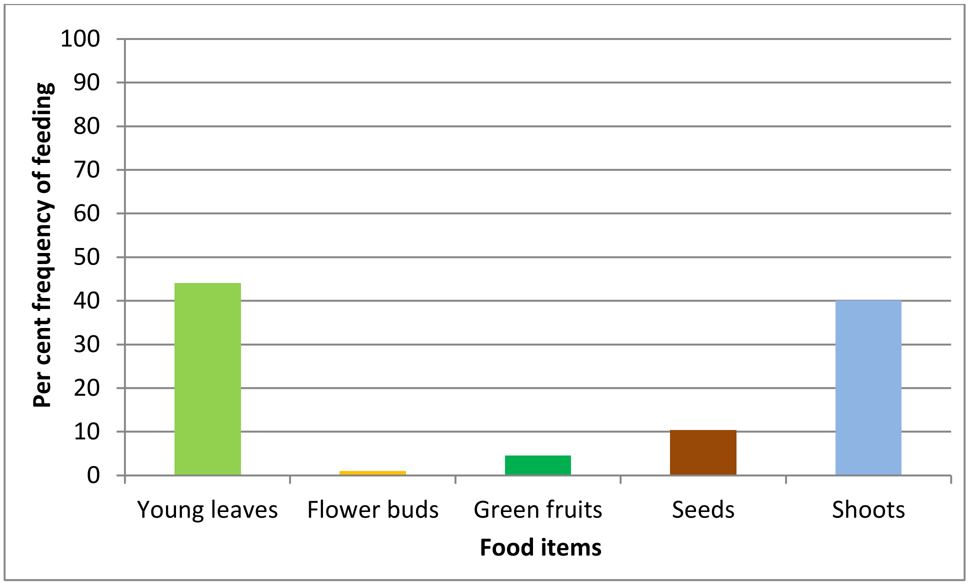


Figure 6.20: Per cent frequency of feeding on food items performed by the sub-adult females of this study group of Proboscis Monkey in Kuching Wetland National Park

Adult Male The adult male most frequently engaged in feeding on young leaves which accounted for 80.4 per cent of the feeding events observed (Figure 6.21). Shoots, seeds and flower buds accounted for 10.6 per cent, 7 per cent and 2 per cent of feeding events. It did not engage in feeding on green fruits.

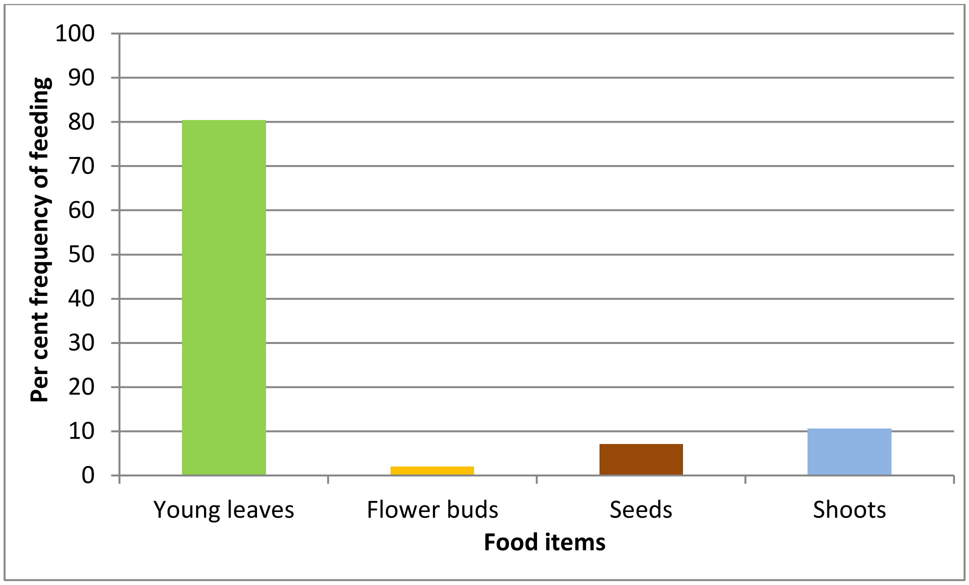


Figure 6.21: Per cent frequency of feeding on food items performed by the adult male of this study group of Proboscis Monkey in Kuching Wetland National Park

Sub-Adult Males Feeding pattern of sub-adult males on some food items in this study group was similar to the adult male. They engaged in 73.6 per cent frequency of their active feeding on young leaves, 10.8 per cent on shoots, 7.3 per cent on seeds, 6.1 per cent green fruits and 2.2 per cent flower buds (Figure 6.22).

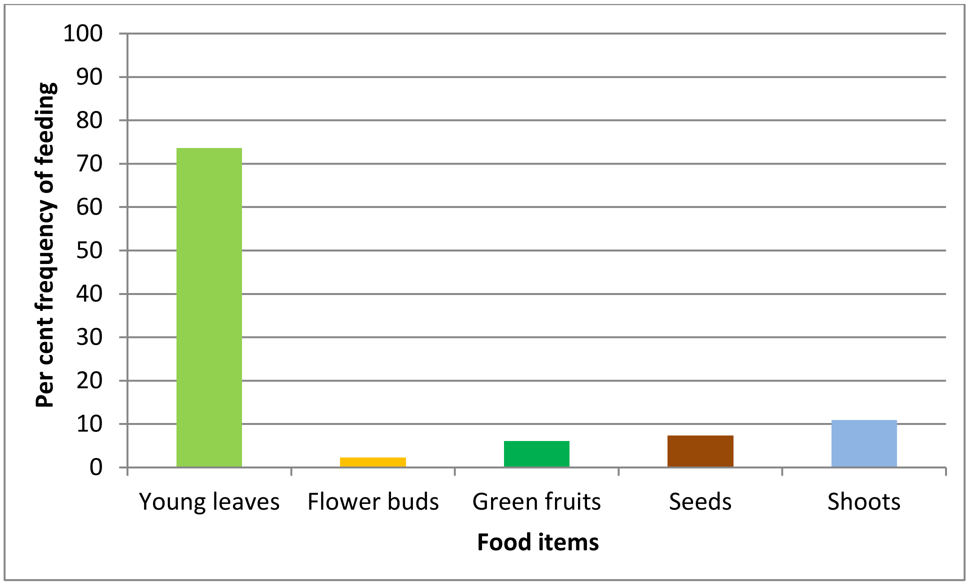


Figure 6.22: Per cent frequency of feeding on food items performed by the sub-adult males of this study group of Proboscis Monkey in Kuching Wetland National Park

Juveniles Juveniles' feeding pattern was similar to sub-adult females' (Figure 6.23). They most frequently engaged in feeding on young leaves (50.4%) and shoots (40.8%). Flower buds and seeds occupied at 4 per cent and 3 per cent of their feeding. They also engaged in feeding on green fruits which occupied at 1.8 per cent frequency of their active feeding.

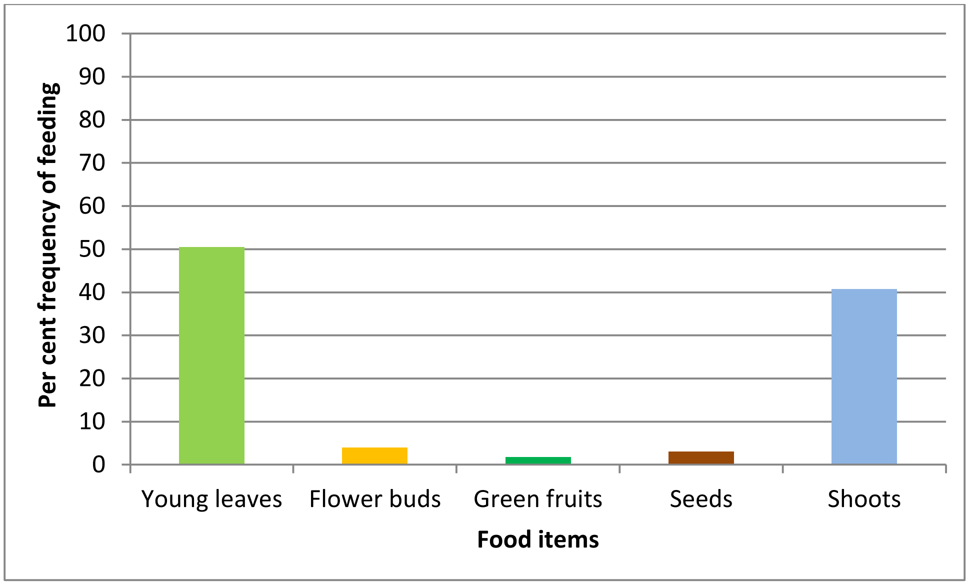


Figure 6.23: Per cent frequency of feeding on food items performed by the juveniles of this study group of Proboscis Monkey in Kuching Wetland National Park

Monthly Food Category Variation

Per cent frequency of monthly feeding in specific study sites

a. Bako National Park

The combined data set for this study group of Proboscis Monkey showed the highest frequency of feeding on young leaves occurred in June 2011 (70.9%), shoots in May 2011 (52.7%), seeds in November 2011 (15.1%), leaf bases in May 2012 (14.1%), flower buds in July 2011 (4.1%), and flowers in May 2012 (5.7%) (Figure 6.24). Feeding on green fruits only occurred in December 2011 (1.1%) and Jan 2012 (1.3%). There was a significant difference between the highest and lowest frequency of feeding events on young leaves in Jun 2011 and May 2012 (n = 133; z = -5.939, $p < 0.01$), shoots in May 2011 and Jun 2011 (n = 132; z = -2.329, $p = 0.02$), seeds in November 2011 and March 2012 (n = 105; z = -5.139,

$p < 0.01$), leaf bases in May 2012 and August 2011 (n = 63; z = -6.586, $p < 0.01$), flower buds in July 2011 and November 2011 (n = 14; z = -3.606, $p = 0.001$), flower buds in July 2011 and December 2011 (n = 25; z = -4.899, $p < 0.01$), flowers in May 2012 and December 2011 (n = 69; z = -5.899, $p < 0.01$).

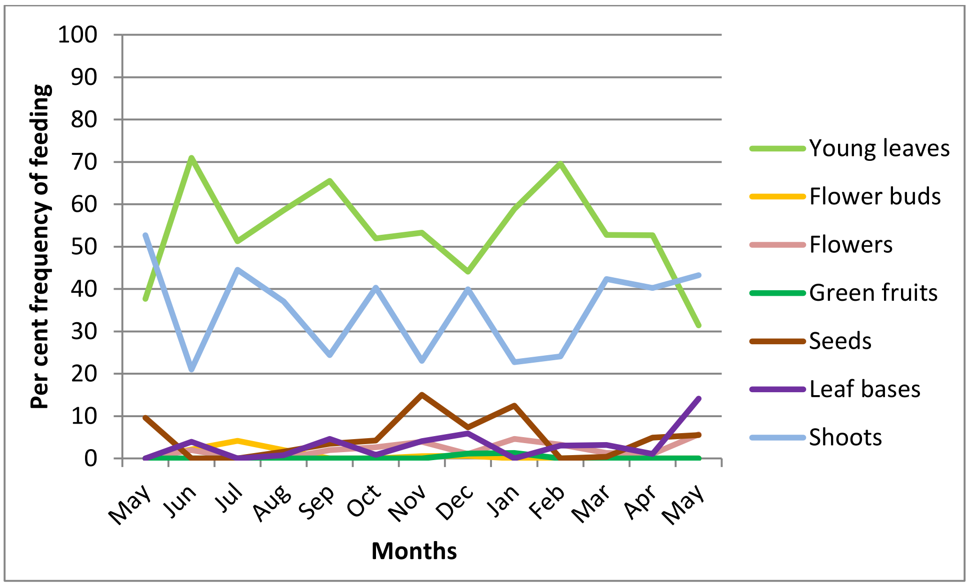


Figure 6.24: Monthly frequency of feeding on food items in Bako National Park

b. Kuching Wetland National Park

Frequency of feeding for this study group varied according to months. These variations were evident between the highest and the lowest per cent frequency of feeding (Figure 6.25) on young leaves in February 2012 (80.7%) and December 2011 (50.9%), shoots in June 2011 (39.4%) and January 2012 (7.6%) , seeds in December 2011 (18.5%) and September 2011 (1.7%), green fruits in November 2011 (7.2%) and September 2011 (1.7%) and flower buds in December 2011 (7%)

and October 2011 (2.3%). Variation between the highest and the lowest frequency of feeding was significantly different in young leaves in February 2012 and December 2011 (n = 259; z = -10.619, $p < 0.01$), seeds in December 2011 and September 2011 (n = 130; z = -3.045, $p = 0.002$), and flower buds in December 2011 and October 2011 (n = 63; z = -2.114, $p = 0.03$). There was no significant difference in frequency of feeding on shoots between June 2011 and January 2012 (n = 252; z = -0.464, $p > 0.05$). Analysis for frequency of feeding on green fruits between November 2011 and September 2011 could not be performed due to insufficient data.

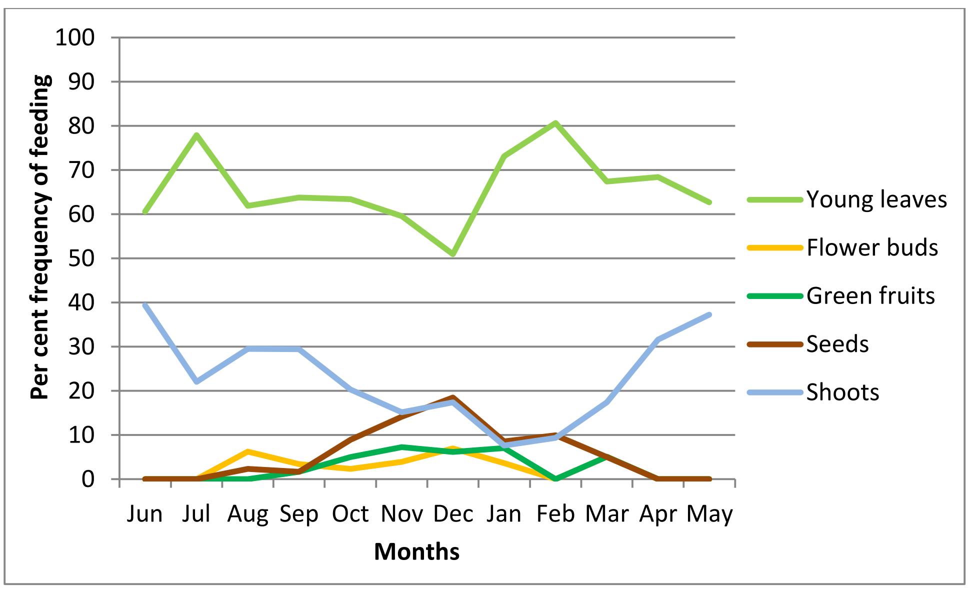


Figure 6.25: Monthly frequency of feeding on food items in Kuching Wetland National Park

Seasonal Food Category Variation

Per cent frequency of feeding according to seasons

a. Bako National Park

This study group showed variation in feeding on food item categories between the wet and the dry seasons (Figure 6.26). They engaged more frequently in feeding on young leaves (56.5%) during the wet season as opposed to the dry season (50%). However, they fed more frequently on shoots during the dry season (39.7%) as opposed to the wet season (27.5%). Variation was also evident in frequency of feeding on other food items. They engaged more frequently in feeding on flower buds (1.6%) and leaf bases (3.8%) during the dry season, and more frequently in feeding on flowers (3.2%) and seeds (8.7%) during the wet season. In the dry season, flowers and seeds occupied 1.5 per cent and 3.3 per cent frequency of feeding respectively. While the frequency of feeding on green fruits was 0.6 per cent during the wet season, there was no record of feeding on this food item during the dry season.

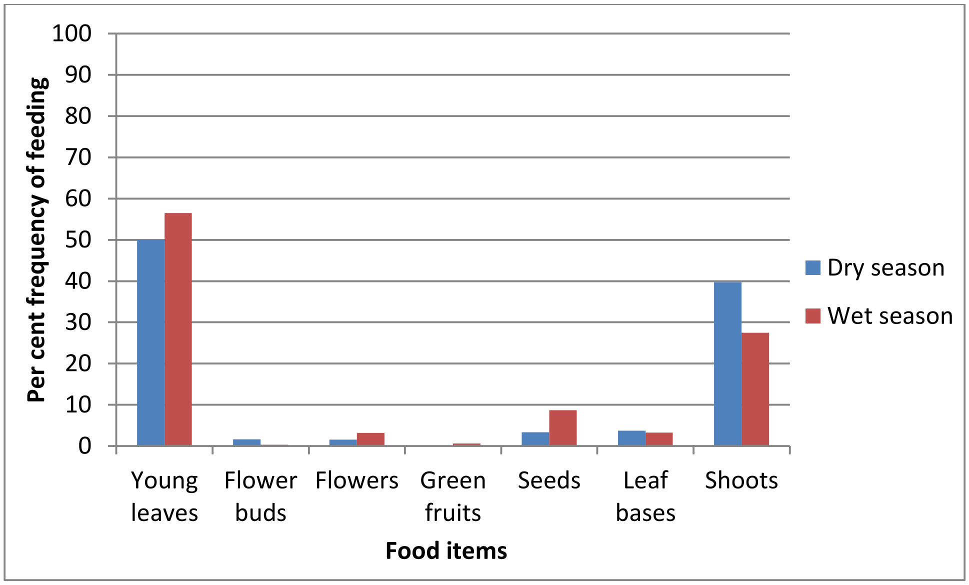


Figure 6.26: Per cent frequency of feeding on food items according to seasons in Bako National Park

The variation in frequency of feeding on food items during the dry and the wet seasons was significantly different for all categories except green fruits - young leaves ($n = 732$; $z = -2.736$, $p < 0.01$), flower buds ($n = 55$; $z = -6.606$, $p < 0.001$), flowers ($n = 116$; $z = -8.336$, $p < 0.001$),seeds ($n = 212$; $\chi^2 = 87.245$, d.f. 1, $p < 0.001$), leaf bases ($n = 246$; $z = -2.645$, $p = 0.008$) and shoots ($n = 1221$; $z = -7.137$, $p < 0.001$).

b. Kuching Wetland National Park

Variation in frequency of feeding according to food categories between the wet and the dry seasons was also evident in this study group (Figure 6.27). They engaged more frequently in feeding on young leaves during the wet season (66.1%) as opposed to the dry season (65.8%). Frequency of feeding on flower buds was the lowest (3.6%) among the food items during the wet season. Frequency of feeding on green fruits was 5.1 per cent, whereas a similar frequency of feeding on seeds (12.8%) and shoots (12.4%) during the wet season was recorded. They engaged most frequently in feeding on shoots during the dry season (32.1%) compared to the wet season (12.4%). Frequency of feeding on flower buds and seeds were 1.6 per cent and 0.6 per cent respectively during the dry season. Similar to Bako National Park, there was no record of feeding on green fruits during the dry season.

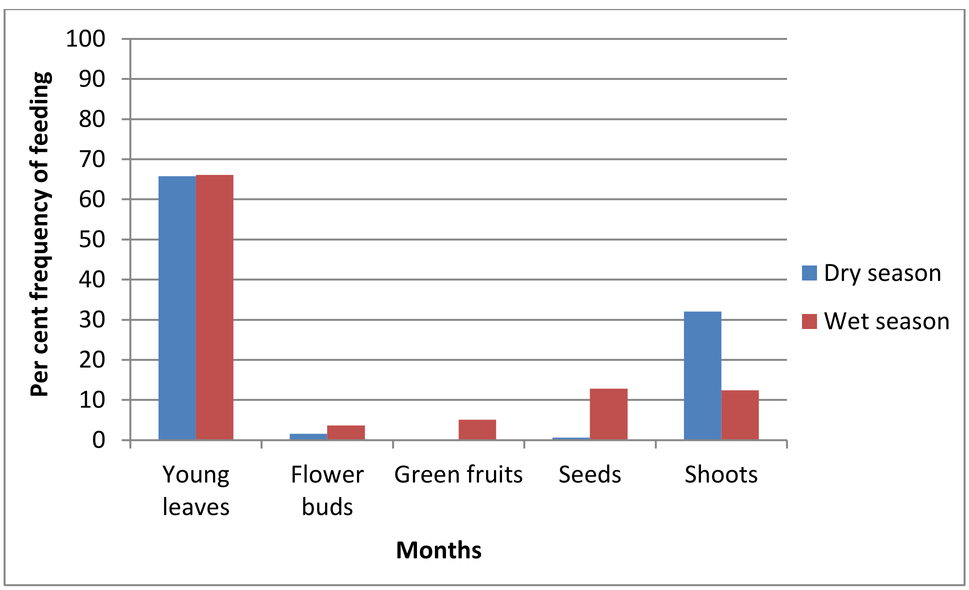


Figure 6.27: Per cent frequency of feeding on food items according to seasons in Kuching Wetland National Park

Variation between the dry and the wet seasons was evident with a significant difference in the frequency of feeding on young leaves (n = 1249; z = -6.115, *p*<

0.001), flower buds (n = 133; z = -4.109, $p < 0.001$), seeds (n = 264; z = -3.934, $p < 0.001$) and shoots (n = 1249; z = -7.764, $p < 0.001$).

Relationship between Food Item Intake and Feeding Frequency

a. Bako National Park

There was a small and positive correlation between frequency of feeding and feeding on young leaves. This correlation was significantly different (n = 126; *rho* = 0.215, $p = 0.015$) with high frequency of feeding associated with high intake of young leaves. The relationship between frequency of feeding and the intake of other food items was not significantly correlated (frequency of feeding and flower bud-feeding (n = 5; *rho* = 0.1, $p = 0.873$), frequency of feeding and flower-feeding (n = 18, *rho* = 0.035, $p = 0.892$), frequency of feeding and seed-feeding (n = 37, *rho* = -0.141, $p = 0.404$), frequency of feeding and leaf base-feeding (n = 26; *rho* = -0.192, $p = 0.359$), frequency of feeding and shoot-feeding (n = 112; *rho* = -0.128, $p = 0.179$). The analysis between feeding and green fruit-feeding was not performed due to insufficient data.

b. Kuching Wetland National Park

In Kuching Wetland National Park, there was a significant correlation between frequency of feeding and green fruit-feeding (n = 16; *rho* = 0.580, $p = 0.018$) with high frequency of feeding associated with high intake of green fruits. The relationship between frequency of feeding and the intake of other food items was not significantly correlated (frequency of feeding and young leaves-feeding (n = 146; *rho* = 0.116, *p* = 0.163), frequency of feeding and flower bud-feeding (n = 17; *rho* = 0.057, *p* = 0.827), frequency of feeding and seed-feeding (n = 35; *rho* = 0.278, *p* = 0.105), feeding of feeding and shoot-feeding (n = 83; *rho* = -0.007, *p* = 0.950).

Water Intake

a. Bako National Park

Sources of water for this study group of Proboscis Monkey were holes in tree branches and base of leaves in the *Pandanus* sp., water pools on the forest floor and in rocks, small streams in the mangrove and heath forests, and water that flows down leaves during rain periods. Over the study period, a juvenile was found on 12 occasions to drink water from a hole in a tree branches and at the base of leaves of the *Pandanus* spp. The adult male was found on 10 occasions to drink water from water pools in small creek and rock in the heath forest. On seven occasions the adult females and on one occasion lactating females were observed drinking from water pools in the swamp area and the heath forest floor. This study group was found on 31 occasions during the dry season and 25 occasions during the wet season to drink from rain water that flows down leaves, water streams and water pools on the mangrove forest floor (Figure 6.28). But, overall ground foraging including drinking water on the forest floor occupied very little percentage of their behavioural events (see Chapter 5).

Figure 6.28: This study group of Proboscis Monkey drink on the mangrove floor

b. Kuching Wetland National Park

In Kuching Wetland National Park, this study group of Proboscis Monkey rarely ventured down to the forest floor to drink. Over the study period I found juveniles came down to the small stream on 10 occasions during low tide to drink and the adult male on seven occasions. During rain periods, they drank water that flowed down leaves, branches and nipah fronds.

6.3.3 Plants Phenology and Food Seasonality

a. Heath Stands Inside Monitoring Plots in Bako National Park

Flowering and fruiting fluctuated across the period of study suggesting seasonality patterns and monthly variations in productivity. The highest number of flowering events was evident in December 2011 (Figure 6.29), while September 2011 recorded the lowest flowering, and no flowering events occurred in June 2011 and July 2011. Flowering in December 2011 (highest) was not significantly different from flowering in September 2011 (lowest; n = 4; z = -1.225, $p > 0.05$), and fruiting in April 2012 (highest) did not differ significantly from fruiting in July 2011 (lowest; n = 3; z = 0, $p > 0.05$).

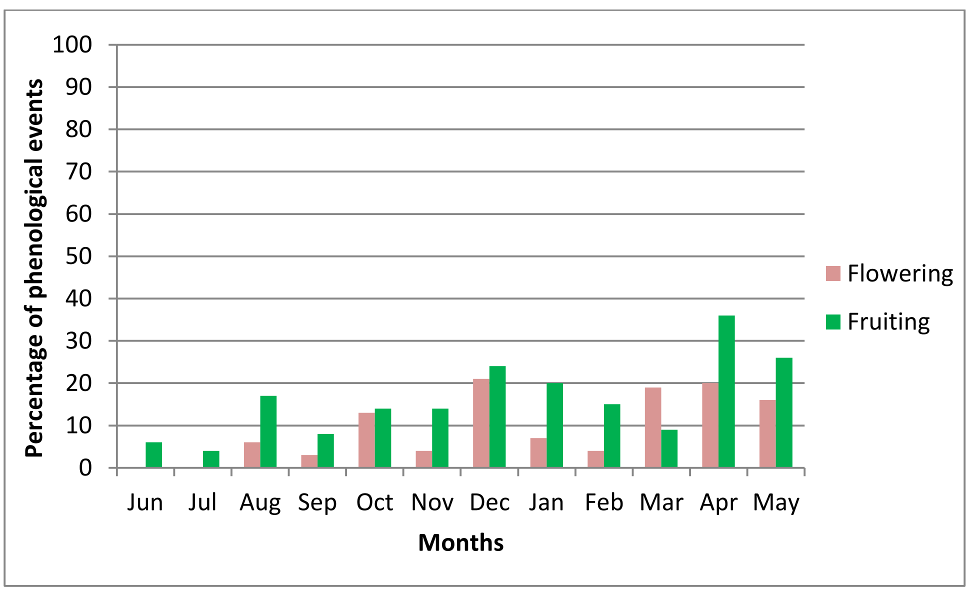


Figure 6.29: Monthly flowering and fruiting of heath stands in monitoring quadrats

Flowering and fruiting was both higher during the wet season (Figure 6.30). However, fruiting was much higher than flowering in both seasons. Flowering between the dry and the wet seasons was not statistically different (n = 58; z = -1.152, $p > 0.05$), but there were significantly more fruiting events during the wet season compared to the dry season (n = 55; z = -2.552, $p = 0.011$).

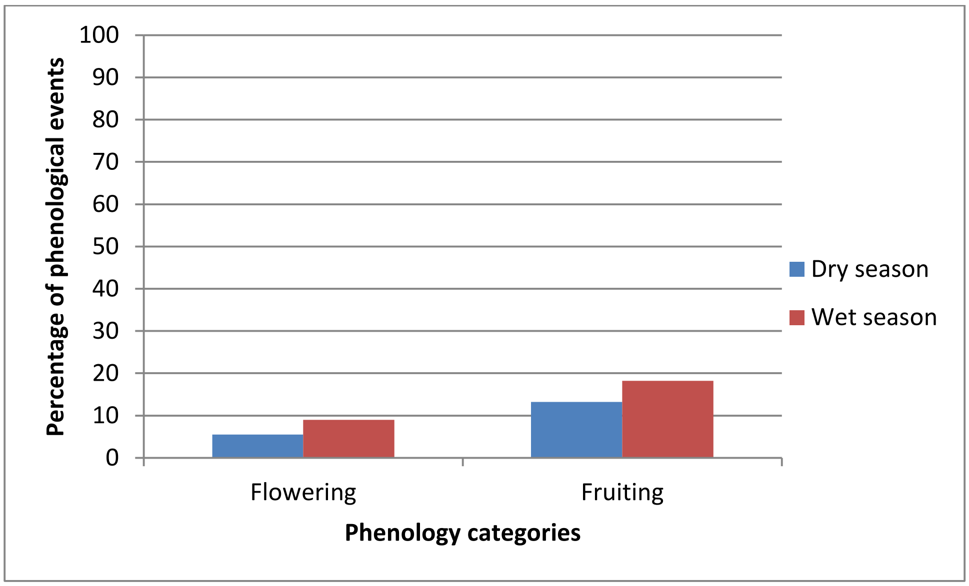


Figure 6.30: Flowering and fruiting in heath forest in monitoring quadrats according to seasons

Table 6.4 Show the mean and standard deviation levels of both flowering and fruiting trees.

Table 6.4: Flowering and fruiting events in heath forests

	Flowering	Fruiting
Mean ± SD	10.0 ± 5.8	15.0 ± 11.5
Range	1 - 19	1 - 35

b. Food Plants Outside Monitoring Plots in Bako National Park

Food plant species that were observed outside the monitoring quadrats but within the heath forests were *Syzygium* sp., *Syzygium adenophylla*, *Garcinia cuneifolia*, *Vitex pubescens*, *Calophyllum lanigerum*, *Termanila cattapa*, *Ficus Benjamin*, *Hibiscus tilliaceus*, *Barringtonia asiatica*, *Pongamia pinnata*, *Lagerstroemia speciosa*. Foliation, flowering and fruiting varied across the period of study (Figure 6.31). These variations suggested seasonality patterns and monthly variations in productivity. The highest and the lowest percentage of foliation events occurred in July 2011 and April 2012 which was significantly different (n = 47; z = -2.938, p = 0.003). Percentage of flowering events was highest in September 2011 and lowest in July 2011, which was also significantly different (n = 58; z = -5.087, $p < 0.001$). Variation in fruiting events was also evident. The highest and the lowest percentage of fruiting events in January 2012 and April 2012 was significantly different (n = 94; z = -5.304, $p < 0.001$).

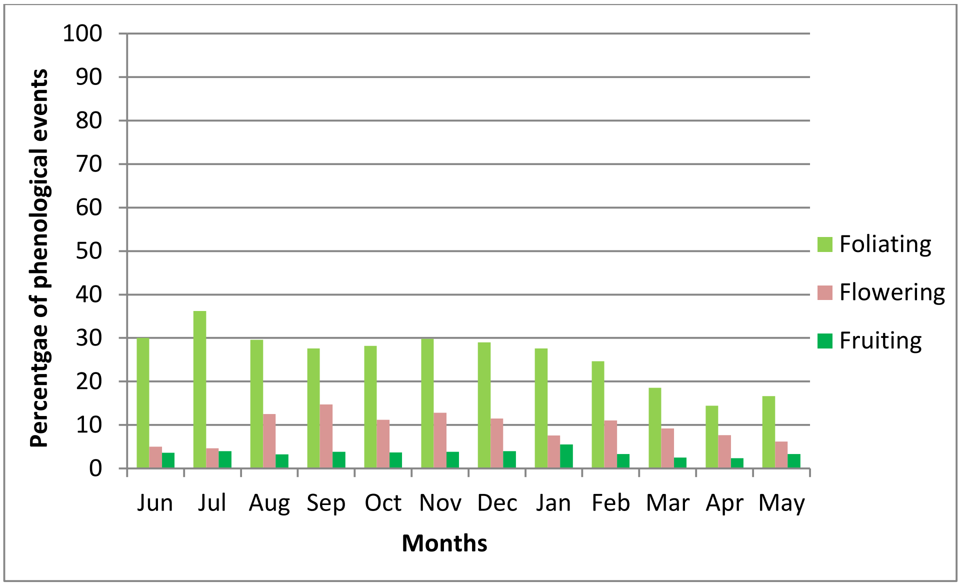


Figure 6.31: Phenology of food plants outside the monitoring quadrats in heath forest

Percentage of foliation events was the highest during both the dry and the wet seasons (Figure 6.32). Foliation was slightly higher during the dry season but not significantly different from the wet season (n = 6060; z = -0.670, $p > 0.05$). Percentage of flowering events was significantly higher during the wet season as opposed to the dry season (n = 820; z = -11.801, $p < 0.001$). Fruiting events during the wet season were also significantly higher compared to the dry season (n = 820; z = -7.174, $p < 0.001$).

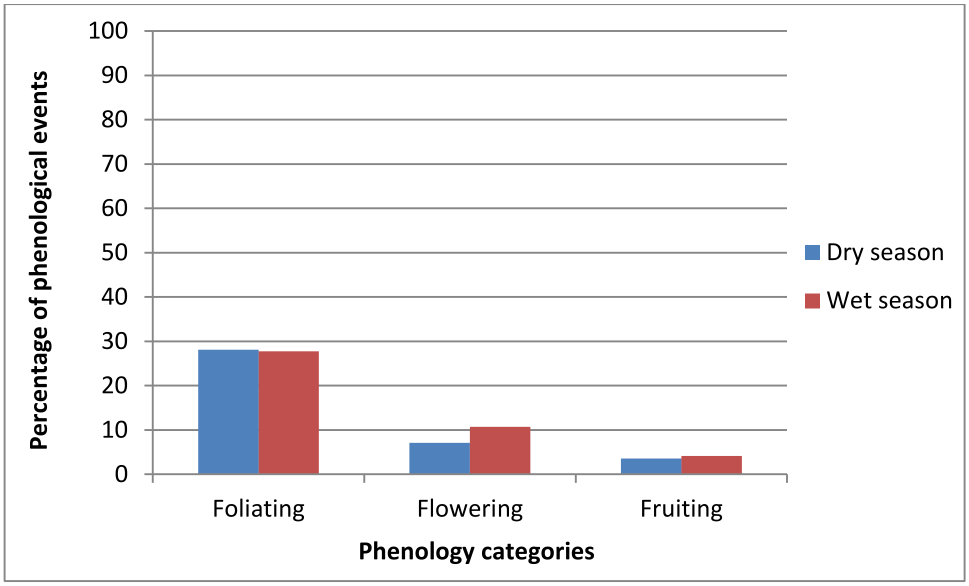


Figure 6.32: Phenology of food plants outside the monitoring quadrats according seasons

c. Mangrove Stands Inside Monitoring Plots in Bako National Park

Production of young leaves, flower buds, flowers and green fruits in the 15 quadrats varied from month to month except ripe fruits that only available in July 2011 (Figure 6.33). Production of young leaves was highest in January 2012 and lowest in May 2012 and this variation was significantly different (n = 551; z = -12.558, $p < 0.001$). Production of flower buds was also highest in January 2012 but lowest in September 2011 which was significantly different (n = 76; z = -5.333, $p < 0.001$). Production of flowers was highest in February 2012, no flowers in December 2011, and the lowest production was in November 2011. Production of flowers between February 2012 and November 2011 was significantly different (n = 29; z = -2.325, $p = 0.02$). Production of green fruits was highest in February 2012 and lowest in January 2012. But there was no production of green fruits in May 2011 and Jun 2011. Production of green fruits in February 2012 was not significantly different from May 2012 (n = 23; z = -0.651, $p > 0.05$).

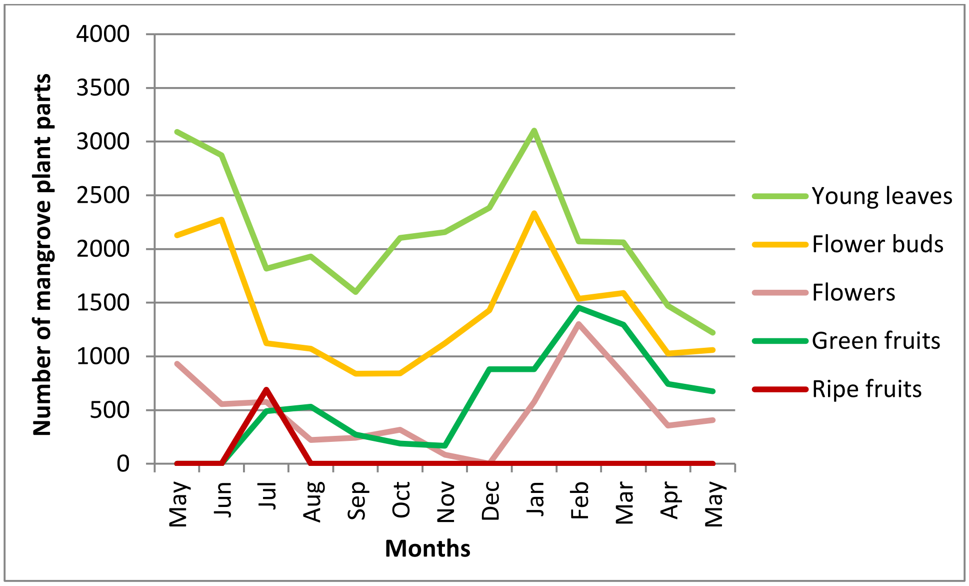


Figure 6.33: Phenology of mangrove forests in Bako National Park

Table 6.5 Below presents the mean and standard deviation levels of the production of each mangrove plant parts from observed mangrove trees in the phenology plots.

Table 6.5: Phenology of mangrove plant parts in Bako National Park

	Young leaves	Flower buds	Flowers	Green fruits	Ripe fruits
Mean ± SD	2102.7 ± 1905.3	1587.9 ± 1601.3	696.6 ± 793.7	821.2 ± 1068.7	690 ± 42.4
Range	90 - 20352	96 - 11700	56 - 6240	56 - 9360	660 - 720

Production of young leaves and flower buds was higher during the wet season as opposed to the dry season (Figure 6.34). Variation in the production of young leaves between these two seasons was significantly different ($n = 99$; $z = -2.626$, $p = 0.009$), but variation in the production of flower buds between the dry and the wet seasons was not significantly different ($n = 66$; $z = -0.796$, $p > 0.05$). Production of flowers was slightly higher during the dry season as opposed to the wet season, but this was not significantly different ($n = 40$; $z = -1.056$, $p > 0.05$). Production of green fruits was also not significantly different between the dry and the wet seasons ($n = 30$; $z = -0.988$, $p > 0.05$). Statistics could not be computed for ripe fruits due to not enough valid cases.

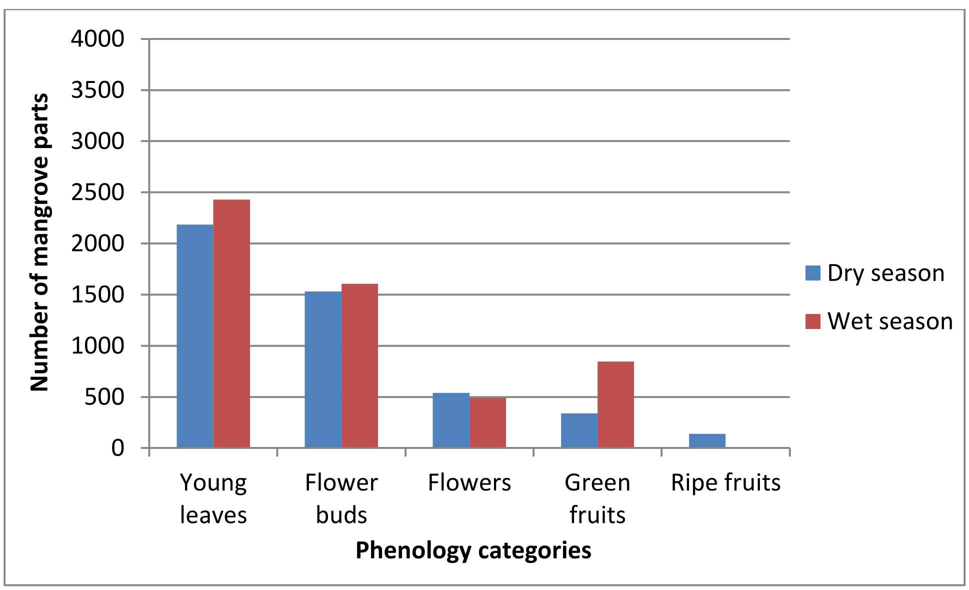


Figure 6.34: Phenology of mangrove forests according to seasons in Bako National Park

d. Mangrove Stands Inside Monitoring Plots in Kuching Wetland National Park

Monthly production of young leaves, flower buds, flowers, green fruits and ripe fruits in the 25 quadrats varied (Figure 6.35). Production of young leaves was highest in April 2012 and lowest in August 2011 which was significantly different (n = 1000; z = -12.391, $p < 0.001$). Production of flower buds was highest in May 2012 and lowest in August 2011 which was significantly different (n = 62; z = -2.005, $p < 0.05$). Production of flowers was also highest in May 2012 but lowest in March 2012, but there was no significantly different between these two months (n = 21; z = -1.651, $p > 0.05$). Production of green fruits was highest in January 2012 and lowest in July 2011 which was significantly different (n = 30; z = -2.089, $p<0.05$). February 2012 and May 2012 showed the highest and the lowest production of ripe fruits which was significantly different (n = 8; z = -2.249, $p < 0.05$).

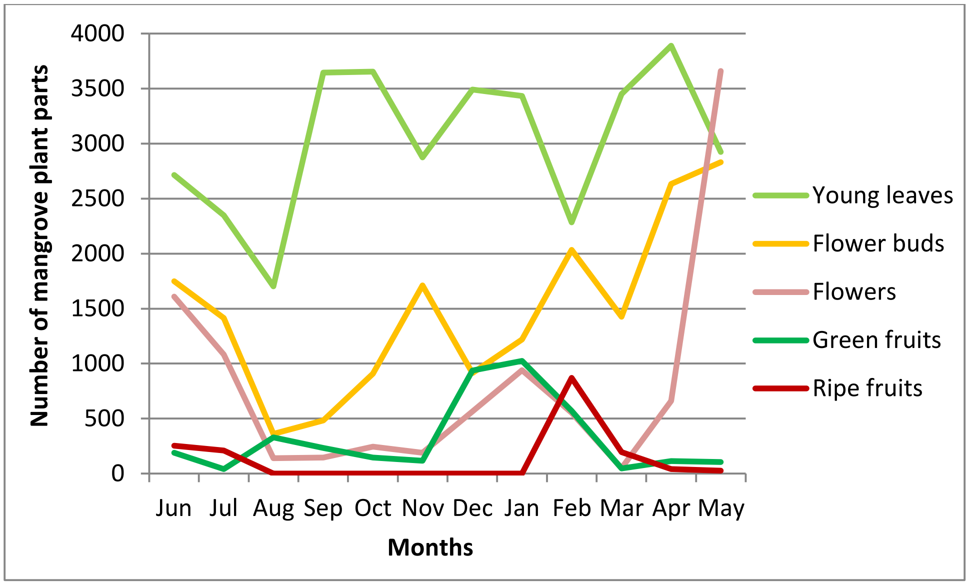


Figure 6.35: Phenology of mangrove forests in Kuching Wetland National Park

Table 6.6 below outlines the mean and standard deviation figures of production of mangrove plant parts from observed trees in the phenology plots

Table 6.6: Phenology of mangrove plant parts in Kuching Wetland National Park

	Young leaves	Flower buds	Flowers	Green fruits	Ripe fruits
Mean ± SD	3034.9 ± 3019.2	1676.4 ± 2190.3	1328.0 ± 2001.9	446.0 ± 719.9	311.9 ± 407.8
Range	40 - 28224	40 - 11253	40 - 8833	20 – 3740	20 - 1800

Similar to Bako National Park, production of young leaves and green fruits was higher during the wet season as opposed to the dry season (Figure 6.36). Conversely, flower and flower bud production were higher during the dry season as opposed to the wet season. There was significantly different between the dry and the wet seasons in production of young leaves ($n = 200$; $z = -4.331$, $p<0.001$) and flowers (n = 29; z = -2.171, *p* = 0.03). But there were no statistically significant in the production of flower buds (n = 54; z = -1.794, *p* > 0.05), green fruits (n = 26; z = -1.415, *p* > 0.05) and ripe fruits (n = 7; z = -0.391, *p* > 0.05).

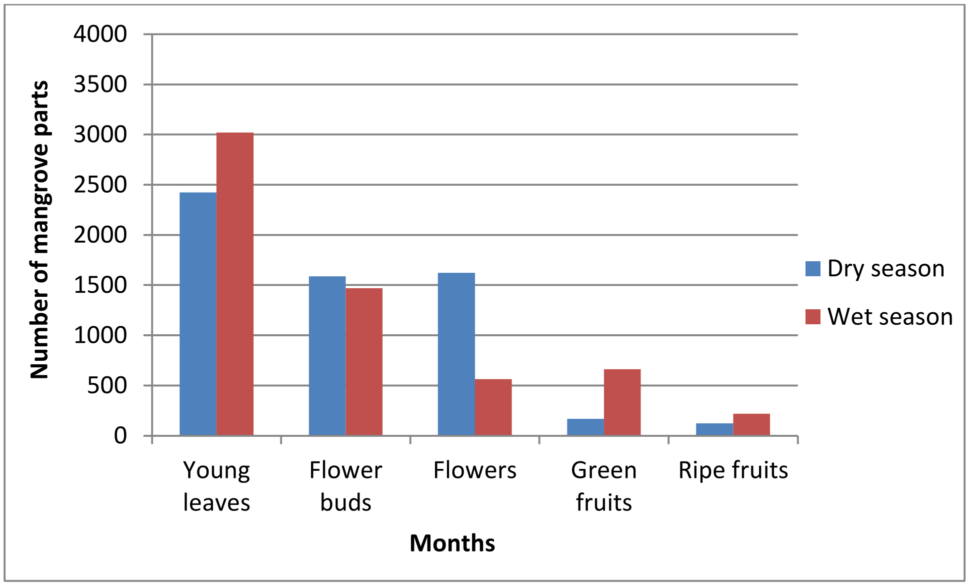


Figure 6.36: Phenology of mangrove forests according to seasons in Kuching Wetland National Park

Relationship between Plant Phenology and Feeding

a. Heath Stands Inside Monitoring Plots in Bako National Park

For heath forest, there was no significant correlation between feeding and flowering events (n = 21; *rho* = 0.147, *p* = 0.524) and also no significant correlation between feeding and fruiting events in heath forests (n = 25; *rho* = 0.164, *p* = 0.434).

b. Food Plants Outside Monitoring Plots in Heath Forest in Bako National Park

There was a positive correlation between feeding and percentage of foliation but this correlation was not statistically significant (n = 12; *rho* = 0.023, *p* = 0.944). There was also no significant correlation between feeding and percentage of flowering (n = 12; *rho* = 0.537, *p* = 0.072), feeding and percentage of fruiting (n = 12; *rho* = 0.282, *p* = 0.374) of food plants.

c. Mangrove Stands Inside Monitoring Plots in Bako National Park

There was no significant correlation between feeding and the production of young leaves (n = 38; *rho* = 0.047, *p* = 0.778) and also no significant correlation with production of other food items (feeding and production of flower buds (n = 25; *rho*= 0.221, *p* = 0.289), feeding and production of flowers (n = 16; *rho* = 0.233, *p* = 0.386), feeding and production of green fruits (n = 18; *rho* = 0.369, *p*> 0.132).

d. Mangrove Stands Inside Monitoring Plots in Kuching Wetland National Park

There was a positive and moderate correlation between feeding and the production of young leaves (n=37; *rho* = 0.387, *p* = 0.018) with more frequency of feeding associated with higher production of young leaves of mangrove stands. As young leaves constituted a considerable component of the food intake of this study group of Proboscis Monkey, increase in the production of young leaves and hence their availability would be followed by an increase in feeding on this food item given its preferred food item status. Positive correlation was also evident between frequency of feeding and production of flower buds (n=25; *rho* = 0.004, *p* = 0.984). This relationship, however, was not significantly correlated. Negative correlation between frequency of feeding and production of green fruits was also not significant correlated (n= 21; *rho* = -0.016, *p* = 0.944).

6.4 DISCUSSION

6.4.1 Foraging Strategies

a. Bako National Park

The study group of Proboscis Monkey in Bako National Park spent much of their time foraging in trees. This behaviour is common to arboreal colobines (Agoramoorthy & Hsu, 2005; Bennett & Gombek, 1993; Boonratana, 2000; Matsuda et al., 2008; Yeager et al., 1999) and other arboreal primates (Rasoloharijaona et al., 2008). Foraging in the upper canopy was prefereable to foraging in the lower canopy because the upper canopy may provide abundant healthy food resources. Abiotic factors like sunlight may help develop healthy young leaves in the upper canopy which receives direct sunlight without being filtered or suppressed by other forest canopies (Osada, Takeda, Furukawa & Awang, 2002; van Schaik et al., 1993; Wright & Schaik, 1994). Forest strata in the medium closed heath forest were evident (see profile of stands in Chapter 4) especially in Habitat 1. Habitat use patterns in these different forest strata may relate to seasonal in food availability (Overdorff, 1996), and distribution and abundance of food trees (Bennett, 1986a). The presence of emergent trees (especially *Shorea* spp.) with intact forest structure and connectivity in the medium closed heath forest, in relation to habitat quality may also explain higher foraging activity in the upper canopy. This is consistent with higher activity budgets in the medium closed heath forest (see Chapter 5). Upper canopy of tropical rain forest not only ever-present of young leaves (Osada et al., 2002; van Schaik, 1986) but also provides easy access of arboreal foraging routes. The study group may feel secured foraging in the upper canopy partly due to intact connectivity which provides proper and safe aboreal routes. In the Menanggul River, Sabah arboreal escape routes protect Proboscis Monkey from leopard attack (Bernard et al., 2011; Matsuda et al., 2008; Matsuda et al., 2010). However, the nature of arboreal behaviour of Proboscis Monkey in this study is related to searching for high quality of food, especially young leaves and shoots.

The study group needed to travel from canopy to canopy to search for the quality of food and their monthly foraging route patterns was almost similar. The heterogeneous forest stands tends to facilitate in their choice for food resources. Heterogeneous forest habitat provides spatial heterogeneity of food for many primates and other wild animals (Barton et al., 1992; Brugiere et al., 2002). The monkeys' movement in searching for food may relate to dietary need and changes in food availability in the canopy. Temporal change in food availability has been reported to influence foraging patterns of Proboscis Monkey (Bennett & Davies, 1994; Boonratana, 2000; Yeager, 1989a) and other primates (Chapman et al., 2002; Kirkpatrick, 2007; Lambert, 2007). These foraging patterns were evident when the monkeys' foraging polygons were almost similar in relation to their movement from the medium closed heath forest to the coastal mangrove forest. This partly explains that monthly variation in food resources availability within the foraging polygons may influence the monkeys' foraging activities. This may also suggest that seasonal change (between wet and dry seasons) in food resources availability may influence the foraging strategies. As primate would be able to develop some sensory inputs through experience which help them make efficent decision about food distribution in space and time, food quality and edibility (Dominy et al., 2001), Proboscis Monkey may also have kwoledge and experience about the location of food resources, which may influence their foraging patterns in relation to seasonal change in food resources availability.

The abundance and evenly dispersed of primates' preferred food particularly young leaves in the tree canopy may suggest that the higher feeding activities in the upper canopy and middle canopies. Although this habitat is home to other primates, for example Silvered Leaf Monkey, fighting for food resources did not occur because other leaf-eating primates were rarely found eating the same food species preferred by the study group.

Feeding Activity

The high degree of feeding activity on young leaves and shoots in this study could not be construed that the monkeys are inclined to be folivore as have been reported earlier (Kawabe & Mano, 1972; Kern, 1964; Macdonald, 1982) because they also fed on other food items. Feeding activity in this study is consistent with a previous study in that the monkeys relied heavily on young leaves (Bennett & Sebastian, 1988; Matsuda et al., 2009a) and shoots (Salter et al., 1985) including flowers (Boonratana, 2000; Matsuda et al., 2009a; Salter et al., 1985), and fruits or seeds (Bennett & Sebastian, 1988; Matsuda et al., 2009a; Yeager 1989a). However, the study group also fed on flower buds and leaf bases. The absence of mature leaves in their daily diet may partly due to low content of protein such that these plant parts are not the main colobine diets (Waterman, 1984).

Feeding activity that occurred in both coastal mangrove forest and medium closed heath forest may have a great effect on the monkeys' foraging behaviour in this study compared to Proboscis Monkey living and foraging in one type of habitat. This was evident in monthly variation in feeding activity on every food items except leaf bases. High feeding on young leaves was only obtained from August to September and shoots from July to August. While all age categories demonstrated more varied in feeding activity, lactating females' feeding activity only occurred on shoots and seeds. Each individual of the study group did not feed on all documented food items, but shoots and seeds were fed by all age and gender categories suggesting shoots and seeds are another most preferred food items besides young leaves. Variety in feeding activity may suggest that variety in food resources and most of food items preferred by the study group were available over the entire of study period except the production of food items which were either lower or higher in certain months. The fluctuation in food production has been reported to have influenced feeding activity of many primates besides food scarcity (Harris et al., 2010; Hemingway & Bynum, 2005). Despite feeding on food items were statistically significant according to seasons except green fruits, high feeding on young leaves coincided with high foliation of mangrove trees during the wet season.

There was a positive correlation between feeding and feeding on young leaves where the monkeys tended to feed more young leaves during the wet season when at the times higher foliation of trees in mangrove forests. Moreover, the higher feeding on flowers during the wet season coincided with the higher flowering of trees and food plants in the heath forest. This may suggest that seasonal change in foliation and flowering of food plants may have an influence on the monkeys' feeding on young leaves and flowers. This may also suggest that seasonal distribution and availability of food plants may influence the foraging behaviour of the monkeys. A previous study demonstrated that distribution and availability of food resources influenced foraging behaviour of other primates, for example *Procolobus badius* in Kibale National Park, Uganda (Chapman et al., 2002), *Colobus guereza* in Kibale National Park, Uganda (Chapman et al., 2010) and *Alouatta palliate* in Barro Colorado Island, Panama (Milton, 1980).

The study group remained foraging in their group over the study period except the juveniles which were regularly found solitary. This behaviour was evident as long as there were no disturbances (see Chapter 7). The availability of food determines social behaviour, organization of primates (for example *Lagothrix lagotricha poeppigii* in Yasuni National Park, Ecuador (Fiore, 2004) and *Nasalis larvatus* in Samunsam Wild Life Sanctuary, Sarawak (Rajanathan, 1992)) and group size of Proboscis Monkey (Hon & Gumal, 2004; Rajanathan, 1992). Foraging in group may likely to protect the study group from any threats. In Bako National Park, the major threat within the park is human disturbance because Bako National Park is a Totally Protected Area and Proboscis Monkey is the park flagship. In other areas where Proboscis Monkey is subject to be posed by various threats its foraging behaviour is seriously affected. These threats among other predators (Galdikas, 1985) hunting (Bennett, 1986b) and forest fragmentation (Sha et al., 2008). Therefore, foraging bahviour of Proboscis Monkey in Bako Natonal Park may subject to be influenced by food availability and tourism activity (see Chapter 7).

b. Kuching Wetland National Park

The riverine mangrove provided the quality of food resources for Proboscis Monkey especially young leaves. Young leaves production of mangrove trees was higher in Kuching Wetland National Park as opposed to mangrove in Bako National Park. Young leaves are the main source of food for Proboscis Monkey which are mostly found at the upper canopy. This may suggest 99 per cent of the foraging activity occurred in the tree canopy especially at Top Level Crown (Level 1), and Middle Level Crown (Level 2) of mangrove trees. Foraging in different canopy level may due to availability of food resources (Salter et al., 1985). Given the quality habitat in Kuching Wetland National Park, food resources in the upper canopy is found in close proximity to their sleeping sites which could reduce travelling cost. Higher tree foraging during the wet season coincided with higher production and higher intake of food items during the wet season, particularly the production of young leaves which was higher during the wet season. This is consistent with higher tree foraging in Level 1 and Level 2 of tree crown during the wet season.

Foraging patterns were similar because foraging occurred within the confines of foraging polygon in a single habitat. Crown connectivity in this habitat provides good arboreal foraging routes such that less foraging occurred on the ground. Despite tree foraging occurred during high and low tide, ground foraging that occurred during the low tide indicated that crocodile attack on the monkeys were not of great concerns. Unlike in Tanjung Puting National Park, Indonesia where a crocodile, false gavial was reported preying on Proboscis Monkey swimming across a river (Galdikas, 1985; Yeager, 1991a). However, there were a number of crocodile attacks on village folks and domestic animals at this study site (per. com with Kg Salak folks).

Foraging near the river edges was a common daily activity of this study group because the area is dominated by their preferred food resources from the species of *Sonneratia alba*. Food items especially young leaves of mangrove species were available throughout the study period although monthly production varied. This may explain the study group would rather prefer foraging in central polygon (see Chapter 5) of the habitat. However, the availability of preferred food resources may suggest that no foraging occur ouside this habitat. In addition they may need to return to trees near the river edges every night in this habitat (Bennett & Sebastian, 1988; Matsuda et al., 2009b). As reported in previous studies, Proboscis Monkey travelled farther when feeding on young leaves increased (Boonratana, 2000; Matsuda et al., 2009a; Matsuda et al., 2009b). The foraging range may be larger during the period of scarcity of food and they may consume other types of food.

The forest structure and connectivity in this habitat (see Chapter 4) may suggest no further movement to the end of branch of trees and thus less travel cost incurs. In addition irregular orientation and position of branches have been reported to have caused much movements in arboreal primates to reach the food that mostly occur at the tip of branches (Cant, 1992). Some twigs along the branches provided some young leaves and even fruits preferred by the monkeys which not only provide enough food but also could provide a strong support for their body weight. This may explain that much time spent feeding in a single tree.

Feeding Activity

Feeding frequency on young leaves of mangrove in Kuching Wetland National Park was much higher as opposed to mangrove in Bako National Park. High frequency of feeding on young leaves of mangrove during the wet season which mostly occurred in February coincided with high production of young leaves during the wet season. Moreover, the relationship between feeding activity and production of young leaves of mangrove was also significantly different suggesting foliation of mangrove stands may become an important factor influencing foraging activity of the monkeys in this study. High production of young leaves during the wet season is consistent with a previous study that showed the production of new leaf of mangrove occurred during the wet season (Coupland et al., 2005). This variation is supported by a significant difference in frequency of feeding on young leaves between the dry and the wet seasons. On the other hand, the higher frequency of feeding on shoots was during the dry season, especially in June. This suggests that diet composition of Proboscis Monkey varied and was influenced by seasonal change in availability of resources.

Feeding on green fruits which mostly occurred during the wet season coincided with the higher production of green fruits during the wet season suggesting seasonal change in fruting may have an influence on feeding activity on green fruits. Similar to Bako National Park, feeding activity on seeds in Kuching Wetland National Park was the third most frequently eaten plant parts after young leaves and shoots. Varied in feeding activity may suggest that availability of resources and diet adaptation on certain food items in relation to seasonal change in plant phenology. Primates have been reported to have consumed fallback food when their preferred quality food in scarcity (Grueter et al., 2009; Marshall et al., 2009). In this study, frequency of feeding on flower buds was higher during the wet season although the production of this food items was lower during the wet season suggesting no scarcity of food resources over the study period. The study group had other choice of food items which they mostly preferred like young leaves and shoots. This is supported by feeding activity of all age and gender categories which differed among each other. Adult male and sub-adult males showed their feeding activity on young leaves were higher than other age and gender categories. Although previous studies on feeding ecology and activity budget of Proboscis Monkey (Matsuda, 2008; Matsuda et al., 2009a; Yeager 1989a; Yeager et al., 1999) are well documented, diet of specific age and gender categories in this study may contribute further to an understanding of foraging strategy. The irregularity in feeding in this study may either follow seasonal change in habitat attributes, especially food plants or otherwise depending on the availability of food resources. In central Gabon, most primates feed more on non-fruit food when scarcity in fruits, but at the same time Chimpanzees (*Pan troglodytes*) and three species of Guenons (*Cercopithecus* spp.) still maintain their feeding on fruits (Tutin et al., 1997).

All age and gender categories showed higher feeding on young leaves. Although varied in feeding activity, adult male did not feed on green fruits. Variation in feeding activity suggests that food resource is available either during the wet or the dry seasons in this study. They fed on similar food items but their feeding frequency differed. This demonstrates that the study group may have learnt feeding in group when they were young and the similar food preferences were transmitted till they matured. This foraging behaviour is consistent with previous studies on Proboscis Monkey (for example, Bennett & Sebastian, 1988; Bismark, 2010; Hon & Gumal, 2004; Rajanathan, 1992) and other primates, for example *Gorilla gorilla beringei* (Watts, 2005). In this habitat, food sources especially young leaves were ever-present over the study period. High feeding activity on young leaves suggests that these plant parts are the most preferred food resources partly due to mineral content (Yeager et al., 1999) such that feeding strategy is directed to feed on young leaves. They seemed to have known well their preferred food and food location as being shown by similar daily feeding routes and feeding location over the study period. This foraging behaviour has been documented where primates have goal-directed foraging and ability to compare accurately the distance and directions of feeding (Garber, 1989).

6.4.2 Diet Category

a. Bako National Park

There was a variety of food plants eaten by the study group. Of 53 species of food plants, *Syzygium* spp. (Myrtaceae) and *Garcinia* spp. (Clusiacea) were the most preferred food sources, especially young leaves and shoots. Family Myrtaceae in the park has at least 34 genera and of these 9 genera belong to *Syzygium* spp. whereas family Clusiaceae has at least 29 genera and of these 16 genera belong to *Garcinia* spp. (Wat, 2011). Families Myristicaceae and Fabaceae (Leguminosae) were reported to be an important food sources for primates including Proboscis Monkey in the peat swamp forests of Maludam National Park (Hon & Gumal, 2004) and in Samunsam Wild Life Sanctuary (Bennett & Sebastian, 1988). The higher intake of young leaves and shoots in this study may due to higher content of protein in these food items. Previous studies on feeding ecology of Proboscis Monkey indicated young leaves constituted the largest component of dietary composition (Bennett & Sebastian, 1988; Bismark, 2010; Yeager, 1989a). The high level of young leaves component in primate diet is partly due to high protein-to-fiber ratios (Chapman et al., 2004; Wasserman & Chapman, 2003) and higher quality of food (Harris, 2006).

Seeds of families Myrtaceae, Clusiaceae, Myristicaceae, Sapotaceae, and Rubiaceae were also an important diet for the study group. This indicates that Bako National Park provides more choices of food plants producing seeds preferred by the monkeys. Unlike in Samunsam Wildlife Sanctuary where Proboscis Monkey only consume seeds of families Leguminosea and Myristicaceae (Bennett & Sebastian, 1988), whereas in riverine forests along the Menanggul River, species of families Euphorbiaceae, Lophopyxidaceae, and Mrytaceae were commonly eaten by the monkeys (Matsuda et al., 2009a). As Bako National Park is composed of coastal mangrove, riverine forests, beach forest, cliff vegetation, mixed dipterocarp forests and heath forests, plant compositions may have an influence on the monkeys' diet. This was evident when the study group consumed different species of food plants. Consumed different species may reduce potential toxins from any one of species (Boonratana, 1993).

Different habitats may have different distribution and availability of food resources both spatial and temporal. A previous study demonstrated that Proboscis Monkesy were able to use food sources unavailable to other primates, especially during times of low food availability was probably as the result of specialized physiological adaptations (Yeager, 1989a). Mangrove species especially *Sonneratia alba* was the preferred food resources in the coastal mangrove although this habitat was slightly poor (see Habitat 3 in Chapter 5). In Labuk Bay Sabah where lowland forests have been replaced by agriculture plantation and only mangrove is available, Proboscis Monkey is adapt to survive with diet that is high in sodium content (Agoramoorthy & Hsu, 2005). The study group was not depending so much on the coastal mangrove in this study because they engaged more in feeding in the medium closed heath forests (see Chapter 5). The higher density of preferred food plants in the medium closed heath forest (see Chapter 4) may likely to influence their foraging activity. Although species diversity may decrease due to increase in habitat heterogeneity (Sullivan & Sullivan, 2001), different types of habitat may demonstrate diversity of food availability and provide more choices for the monkeys' diet.

The study group also consumed unripe fruits or green fruits. The absence of ripe fruits in their diet may due to higher sugar content in ripe fruits (Waterman, 1984) that induce increased fermentation and bloat which can quickly kill the monkeys (Bennett & Gombek, 1993). Green fruits represented a little component of their diet compared to seeds which were the second large component after young leaves and shoots. This explains that fruits were not as important as seeds in daily diet of the monkeys. The availability of young leaves and shoots which were the most preferred diet categories may suggest low level of fruits-eating activity. Unripe fruits or green fruits may not an important diet category for the study group although these food resources were available throughout the study period. This contributes to explanations of feeding flexibility where feeding on unripe fruits or green fruits which occurred in certain months (July and December) of the year was not influenced by seasonal change in fruiting events.

This study also revealed that Proboscis Monkey consumed flower buds which were much higher than their consumption on green fruits. This may partly due to flower buds could be much easier to find out because a few food plants species produced more flowers than fruits over the study period. Flower buds-feeding was absent in dietary composition of Proboscis Monkey in previous studies on feeding ecology (Bennett & Sebastian, 1988; Bismark, 2010; Matsuda et al., 2009a; Yeager, 1989a). This may partly due to production of flower buds was not an important event in the phenology of food plants these studies compared to flowers which resulted in grouping these two plant parts under flowers. In this study production of flower buds was the second largest phonological event of food plants and available the entire the study period. Although flower buds-feeding constituted a small component of feeding activity, it may suggest dietary flexibility and an important diet composition of colobines.

Moreover, the presence of flowers in Proboscis Monkey's diet in this study is consistent with a previous study by Salter et al. (1985). The significant flowers-feeding between wet and dry seasons indicated diet adaptability of Proboscis Monkey in relation to diet requirements at the times when the avalibility of food resources were higher during certain months of the year. The availability of other food resources may suggest that low frequency of flowers-feeding in this study which is consistent with Bennett & Sebastian (1988), Bismark (2010), Matsuda et al. (2009a) and Yeager (1989a).

However, there was no report of Proboscis Monkey eating leaf bases prior to this study. Leaf bases intake was higher than flowers, flower buds and green fruits suggesting the importance of this food item in the monkeys' diet. This indicates that variability of diet due to resource availability. Feeding on leaf bases was significantly different between the wet and the dry seasons suggesting that Proboscis Monkey may have specific diet requirements in relation to seasonal change in habitat attributes. Higher leaf bases-feeding during the dry season and certain months (May and August) of the year coincided with low occurrence of fruiting and flowering events in the same season. This explains that availability of food resources may influence diet composition of Proboscis Monkey. Although leaf bases may indicate a supplementary diet compared to young leaves and shoots, higher intake of leaf bases compared to flowers, flower buds and green fruits may relate to mineral or toxins content which needs phytochemical analyses.

Monthly intake of food plant parts varied over the study period and not all these plant parts constituted daily diet of every age and gender category. The intake of young leaves was highest in February (wet season) and the lowest in May (dry season). While young leaves were the most preferred diet category, shoots were only the most preferable diet for lactating females. Variability in diet category is a common phenomenon in primates, although a number of them are being categorized as specialists, which show flexibility in feeding behaviour (Chapman, 1988b). In this study, young leaves were the second preferred diet of sub-adult females and juveniles. However, higher composition of young leaves and shoots intake among the females especially lactating females may relate to the nutritional requirements to reproduce and raise healthy offspring (Harris, 2006; Wasserman & Chapman, 2003). Males seemed to eat more young leaves as opposed to females and the adult male consumed more young leaves than the sub-adult males. This is proportional to their body size in particular the adult male which is much larger than other age and gender categories. Although many of food sources consumed by primates do not follow the climatic change of the environments (Chapman et al., 1989; Milton, 1980), the flexibility in diet category intake in this study may partly due to the distribution of food resources from food plant species. This was evident when there was a positive correlation between feeding and young leaves intake, and each age and gender category's food intake differed according to seasons.

The intake of young leaves and shoots between dry and wet seasons was significantly different whereby higher intake of young leaves and shoot during the dry season coincided with higher foliation of food plant during the dry season. This may due to some trees produce localized young leaves (Hemingway & Bynum,

2005) and may flushes in different months in the year which mostly occur during the dry season (Hladik, 1978b). The intake of young leaves during the wet season did not coincide with the higher foliation of mangrove stand during the wet season. This may explain that the monkeys may have more other choices of food during the wet season. This is supported by the higher intake of green fruits during the wet season which coincided with the higher fruiting of heath stands, mangrove stands and food plants during the wet season. Likewise, the higher intake of flowers during the wet season coincided with the higher flowering of heath stands and food plants during the wet season. The intake of flowers between the wet and the dry seasons was significantly different. This indicates that seasonal fruiting and flowering may have an influence on the intake of fruits and flowers. Additionally, their intake of leaf bases and seeds were also higher during the wet season. Conversely, they consumed more flower buds during the dry season although higher production of flower buds occurred during the wet season in the coastal mangrove. This may suggest that the study group may have more other choices of flower buds of other plant species besides mangrove stands during which the availability of other food resources may be limited. Therefore dietary variability or fexibility in Proboscis Monkey in this study may relate to habitat productivity and seasonality. This is inconsistent with Chapman and Lauren (1990) who demonstrated that primates' dietary variability is not related to habitat productivity and seasonality.

The ability of the monkeys switching their diet among the various species of food plants between the wet and the dry seasons in this study may due to availability of food resources. Moreover, seasonal change in various types of food plants in relation to habitat attributes suggesting variability in diet categories in this study. Therefore variability in diet categories may partly due to influence of abiotic factors of the environment (for example sunlight, temperature and precipitation) on the production of food resources. Higher feeding on young leaves was observed in Jun and from February through March and on seeds from October through February. Proboscis monkey in Tanjung Putting National Park, Indonesia, were frugivorous (with emphasis on seeds of unripe fruits) from January through May and folivorous (with emphasis on leaves) from June through December when all fruit abundance increased (Yeager, 1989a). Seasonal fluctuation in feeding activity in Menanggul River, Sabah was influenced by fruit availability and fruit-eating behavior (Matsuda et al., 2009a). These explain that seasonal availability of resources influenced variability in diet categories.

The physical characteristics of plant parts may have an influence on the choice of food sources. This was reflected by sub-adult females, juveniles and lactating females which included a considerable component of shoots than young leaves in their diet. Most of young leaves were wider in size and harder in structure compared to shoots. Shoots on the hand was very easy to recognize through its colour, and its size was much suitable to consume. Some diurnal primates have varying degree of colour vision (Yamashita et al., 2005) which gives the ability for them to increase levels of feeding on a particular food items. Diet categories of sub-adult females and juveniles were similar. Although they had wider opportunity to include more young leaves in their diet during foliation period, and flower buds and flowers during flowering and fruiting seasons, they inclined to favour on shoots. Either there were very little flower buds or flowers produced by the food plants they preferred or these food items were less priority in their daily diet suggesting the small representation of these food items in their daily diet as opposed to young leaves.

Lactating females consumed more shoots from different species of food plants which were the highest intake compared to other food items consumed by other age and gender categories. This explains that shoot was the most preferable food item in lactating females' diet. Shoots were easy to pluck off and also easy to select among the leaves. Shoot was soft and easy for digestion which was much suitable for lactating females that needed to breast-feed her baby. They did not need to engage in more selectivity process to identify shoot among other food items as the study site was composed of various different types of food plants with ever-present of shoots. This would reduce the cost of travelling in lactating females. Morover, the selection of shoots as a preferred diet in lactating females may relate to mineral content. This has been demonstrated by Yeager et al. (1999)

where the available protein in foliage intake is a basis of dietary selection for Proboscis Monkey in Natai Lengkuas, Indonesia.

b. Kuching Wetland National Park

There was not much food plants variety in Kuching Wetland National Park as opposed to Bako National Park because this study group only foraged in one type of habitat. This single habitat is characterized by higher food plant density (see Chapter 4). The mangrove stands in this study is regularly foliating which is consistent with Nowak (2012). Additionally, habitat use of this study group was within the confine of mangrove forest. Unlike in Bako National Park where Proboscis Monkey used both mangrove forests and heath forests vice versa in their daily foraging. The intake of food items varied according to mangrove plant parts and age and gender categories. Most of food plant parts intake was from the family of Sonneratiaceae in particular *Sonneratia alba* and young leaves intake showed the highest frequency. This may explain that young leaves are the most preferred plant parts as opposed to shoots, flower buds, green fruits and seeds. This is consistent with a previous study in similar type of habitat where young leaves were the main diet of Proboscis Monkey (Bennett & Sebastian, 1988; Matsuda et al., 2009a; Yeager, 1989a).

Similar to the study group in Bako National Park, this study group also did not take mature leaves, although in a previous study mature leaves were part of their diet

(Bennett & Sebastian, 1988). This may explain that riverine mangrove (see Chapter 4) provides sufficient young leaves for the monkeys. Moreover, nutrient content is high in young leaves of mangrove (Yeager, 1989a), especially levels of protein, phosphorus, and potassium, and low levels of digestion inhibitors (fiber) (Yeager et al., 1999). The variation in the intake of young leaves including shoots, flower buds and seeds was significantly different between the wet and the dry seasons. A previous study demonstrated that variation in the intake of food items in primate was partly due to spatial and temporal distribution of food plants (Milton, 1981). Additionally, high fruit-feeding was correlated significantly with high feeding frequency. The higher intake of fruits during the wet season coincided with the higher production of fruits during the wet season. This may explain that seasonal fruiting may have an influence on fruit-feeding.

The intake of young leaves in females was much lower than males. In contrast, the intake of shoots was much higher in females than males suggesting that shoots are the most preferred food items in females' diet. However, the higher intake of young leaves and shoots in females may relate to food quality and reproductive success of females (Harris, 2006). Production of young leaves was higher during the wet season, but adult females' intake of this food item was higher during the dry season suggesting the availability of young leaves is not limited according seasons. The higher intake of flower buds during the dry season in adult females coincided with the higher production of flower buds during the dry season. Young leaves intake in adult females did not follow this pattern. As for sub-adult females the higher intake of green fruits and seeds, and lower intake of flower buds may suggest that green fruits and seeds are important diet in sub-adult females. The higher intake of green fruits in sub-adult females during the wet season coincided with the higher production of green fruits during the wet season suggesting seasonal fruiting may have an influence on fruit-feeding in sub-adult females. Moreover, sub-adult females consumed more young leaves during the wet season which coincided with the higher production of young leaves during the wet season. This also suggests that seasonal foliation may have an influence on young leaves-feeding in sub-adult females. Conversely, the intake of flowers, and green fruits in sub-adult females did not follow the same seasonal patterns.

The adult male's food intake did not coincide with any seasonal change in food plants, although it consumed more young leaves and shoots during the dry season and more flower buds and seeds during the wet season. Its intake of any food items may relate to the quality of the food resources. Different age and gender categories may have different caloric needs depending on body size and daily activities (Bismark, 2010). The adult male is much larger than other age and gender categories of this study group, and therefore it needs to eat more. This is consistent with Matsuda et al. (2009a) that focal male spent more feeding than did females. Unlike in St Catherine's island, Georgia, where female prosimian primate engaged more in feeding activity than male (White et al., 2007). Furthermore, adult male did not need to engage in food selectivity. Its experience might have guided the choice on the food item that much suitable to its taste and biological needs. Given this, it did not need to take much shoots and other food items (flower buds and seeds) in its daily diet. The sub-adult males' diet was almost similar to the adult male's. The similarity was partly due to they were in the same gender that inherited the same taste and preferences. Likewise, they also included seeds in their daily diet. The higher intake of green fruits during the wet season in sub-adult males coincided with the higher production of green fruits during the wet season. This explains that seasonal change in green fruit production may influence the intake of these plant parts in sub-adult males.

Juveniles were represented by both genders but their food intake patterns seemed to follow adult females and sub-adult females suggesting age and gender categories also have an influence on dietary patterns. The higher intake of young leaves and shoots in juveniles suggests that these mangrove plant parts are the most preferred food items. The higher intake of young leaves during the wet season in juveniles coincided with the higher production of young leaves during the wet season. In addition, the higher intake of flower buds during the dry season coincided with the higher production of flower buds during the dry season. This may explain that the intake of young leaves and flower buds are influenced by seasonal change in these plant parts. Young leaves and shoots would be the most suitable to them as they were easy to pluck off and also easy to consume compared to flower buds, seeds and green fruits. Flower buds and green fruits were not always available which also explain the lower intake of these food items in juveniles. The absence of flowers in their daily diet suggests that these food items may not their preferred food resources. Overall, this study demonstrated that amount and types of food intake were not only dependent on age and gender categories but also seasonal change in food plants.

6.5 CONCLUSIONS

The two study sites were composed of some food plant species preferred by Proboscis Monkey (Appendix 13) with more choices in the heterogeneous habitat (medium closed heath forest and coastal mangrove) as opposed to one single habitat (riverine mangrove). Different habitat attributes that related to habitat quality were characterized by seasonal change in food plants which influenced foraging behaviour of the monkeys according to age and gender categories. Young leaves and shoots were the most preferred food items to all age and gender categories in both study sites. In Bako National Park, seasonal foliation of food plants in the medium closed heath forest and coastal mangrove forests affected the foraging behaviour of Proboscis Monkey. The higher feeding on young leaves during the wet season coincided with the higher production of young leaves during the wet season in both coastal mangrove and medium closed heath forests. The young leaves-feeding was significantly correlated with the frequency of feeding. The higher feeding on flowers during the wet season coincided with the higher flowering events during the wet season in heath forests. Seasonal fruiting of food plants, heath and mangrove stands affected the foraging behaviour of Proboscis Monkey. The higher feeding on green fruits during the wet season coincided with the higher fruiting events during the wet season in the medium closed heath forests and the coastal mangrove forests.

In Kuching Wetland National Park, seasonal foliation affected the foraging behaviour of Proboscis Monkey. The relationship between feeding and the production of young leaves of mangrove was statistically significant. The higher feeding on young leaves during the wet season coincided with the higher production of young leaves during the wet season. The green fruit-feeding influenced the foraging behaviour in that the higher frequency of feeding was associated with the higher green fruit-feeding. The higher feeding on green fruits during the wet season coincided with the higher production of green fruits during the wet season. The higher feeding on flower buds during the wet season coincided with the higher production of flower buds during the wet season. Flowers were not the preferred food of Proboscis Monkey such that seasonal flowering of mangrove stands did not influence their foraging behaviour.

CHAPTER 7: TRAIL USER-PROBOSCIS MONKEY INTERACTIONS

7.1 INTRODUCTION

This chapter reviews the general concept of visitor-wildlife interactions, and the impacts of wildlife viewing and other visitors' activities on wildlife foraging behaviour. A discussion of these topics permits the formulation of explicit research questions for this component of the research project. A review of related research is cited to set a clear foundation to support the research project and the findings will be discussed within this context.

7.1.1 Wildlife Viewing

Protected areas or national parks are places where the protection of wild animals is a priority. These areas also provide a superior venue for viewing wildlife in their natural setting, and this has consequently become a popular activity in national parks. The increasing trend of visitors accessing national parks is partly due to the fact that they are more likely able to view wildlife in their natural environments (Donovan & Champ, 2009) and also have access to the range of different wildlife attractions that national parks can offer. Viewing wildlife in their natural environments is a real thrill that tourists can experience as opposed to viewing wildlife in a zoo. Viewing wildlife in their natural setting varies according to place, time and wildlife species (Edwards, Parsons, & Myers, 2011). It has been anattracting factor and plays a significant role in local and regional economies for tourist destinations. In Yellowstone National Park, for example, wildlife viewing preferences vary in relation to different species, and importantly it contributes to the economic value of the different wildlife species (Duffield, Neher, & Patterson, 2008).

The economic value associated with wildlife-viewing activities adds credence to long-term conservation efforts as it provides an encouraging economic benefit from nature-based tourism and the ecotourism industry (Glowinski, 2008). Likewise, wildlife viewing has emerged as an important indicator of quality of experience for visitors accessing national parks (Anderson, Manning, Valliere, & Hallo, 2010). As a significant component of nature-based tourism (Hughes & Carlsen, 2007), wildlife tourism in national parks is able to promote a unique experience chain through capitalising on the whole wildlife ecosystem. Given this, wildlife tourism and associated biodiversity experiences have resulted in improving visitor appreciation of the natural environment. The economic benefit and the need to enhance wildlife habitat and its populations have been an effective vehicle for communicating consequences of environmental impacts due to human activity (McCool, 2009). Although wildlife viewing has been an effective mechanism for educating visitors about the conservation of wildlife and protection of biodiversity (Ballantyne, Packer, & Sutherland, 2011), long durations of wildlife viewing and unregulated tourist behaviour in pursuit of more successful wildlife-viewing opportunities affects not only the biodiversity in general, but also wildlife in particular (Mladenov et al., 2007).

Both wildlife ecology and human dimensions of wildlife tourism in protected areas (in particular national parks) (Catlin & Jones, 2010) have to be considered in the development of good management practices in the pursuit of conserving wildlife and providing quality of experience for visitors. The dual functions of national parks, which are conserving wildlife and providing quality of experience for visitors, are interlinked. Merely conserving wildlife without benefiting the community will result in an ineffective conservation effort because most of the national parks, in particular those in less developed countries, are dependent on the support of the community through providing a number of opportunities, including wildlife viewing. On the other hand, too much emphasis on tourism in national parks and less concern for wildlife ecology and its conservation may have adverse effects on wildlife.

Operationally, sustainable wildlife viewing and other aspects of wildlife tourism cannot only focus on economic viability of the activity but also the longevity and well being of the resources. There is consequently the need to minimize pressure on the natural settings in national parks, which originates partly from tourist activity motivated by a genuine interest in wildlife viewing (Higham, Lusseau, & Hendry, 2008). In Bako National Park, wildlife viewing is an integral part of available visitor activities and also one of the primary motives for visitors accessing the park (Budeng, 2004). Activities that involve wildlife in the park, especially the viewing of Proboscis Monkey and other wildlife, are all categorized as non-consumptive activities, whereas hunting and fishing are not allowed under the protected area status of the park.

7.1.2 Visitor Impact on Wildlife

Wildlife is inclined to avoid encounters with humans. Human-wildlife interaction therefore generally occurs when humans, through the pursuit of a particular activity, come into direct or indirect contact with wildlife (Duffield et al., 2008; Gandiwa, 2011; Knight, 2010). Human-wildlife interaction can cause substantial cumulative negative impacts, and can have a considerable influence on behaviour and distribution of wildlife, dependent on the level of disturbance (Griffin, Valois, Taper, & Scott, 2007), types of activities either on-trail or off-trail (Wolf & Croft, 2010), and distance between visitors and wildlife (McLennan & Hill, 2010). The impacts of visitors on wildlife not only result in an inferior visitor experience (Lynn & Brown, 2003) but also can denigrate the quality of wildlife habitat (Ballantyne, Packer, & Hughes, 2009). As wildlife is mobile, tourists engaging in wildlife viewing tend to take advantage of any opportunity to come into close contact, which can lead to serious disturbance of wildlife.

Wildlife disturbed in this way are known to exhibit changes in various behaviours, including reduced mating rate, to spend less time feeding or resting and to use more energy to remove themselves from sources of disturbance (Bouros, 2012). In Montana USA, visitor activities reduced the feeding time of Grizzly Bear (*Ursus arctos horribilis*) by 50 per cent, movement or travelling was increased by 52 per cent and aggressive behaviour increased by 23 per cent (Blanc, Guillemain, Mouronval, Desmonts, & Fritz, 2006), all considerable consequences of such tourist-wildlife encounters. Tourists affect wildlife species differently according to the type of activities they engage in (Johns, 1996). Moreover, in Lamanai, Belize, number of tourists, duration of encounter and behaviour of tourists were found to influence the response behaviour of Black Howling Monkey (*Alouatta pigra*) differently according to their age and their position in the canopy (Treves & Brandon, 2005). Although the effects of wildlife viewing on wildlife vary, most can be categorized as direct but not immediately obvious, such as an increace in stress levels causing disruption of animals' activity patterns, and/or displacement (Cassirer, Freddy, & Ables, 1992; Green & Higginbottom, 2000; Higham & Shelton, 2011). In addition, some wildlife are exposed to visitor activities throughout the year in national parks, which may have indirect effects on their health (Westin, 2007).

Displacement of wildlife from trails due to visitor activities affects wildlife seriously (Griffin et al., 2007), especially when it interferes with accessing food sources, disturbs their breeding behaviour and to a wider extent alters their home range (Curry, Moore, Bauer, Cosgriff, & Lipscombe, 2001). These are dependent on the type of disturbance (Higham & Shelton, 2011) that triggers different responses of wildlife (Blanc et al., 2006; Blom, Cipolletta, Brunsting, & Prins, 2004; Knight, 2009; Werdenich et al., 2003). In response some wildlife reduce their food intake and/or shorten their foraging times, although under some circumstances, they can become habituated to disturbance (Blanc et al., 2006). While habituation can be a minor short-term impact of visitor behaviour for certain wildlife species in their natural setting (Blom et al., 2004), different wildlife species do not have the same capacity for habituation (Blanc et al., 2006; van Krunkelsven, Dupain, van Elsacker, & Verheyen, 1999).

7.1.3 Park Visitors

Bako National Park is a popular national park of Sarawak. It receives visitors in increasing numbers every year, with foreign visitors outnumbering local visitors. Based on visitor statistical records for 2009, 2010 and 2011, the peak seasons for visitation to Bako National Park were July and August (SFC, 2011). The peak period for foreign visitors in July and August mirrored the summer school holidays in Europe, the source of the highest number of foreign visitors (Budeng, 2004). December and January recorded the lowest number of visitors accessing the park. While the nationality of visitors is not able to be confirmed in this study it is known that Bako National Park has been able to attract an increasing number of foreign visitors (SFC, 2011).

The popularity of Bako National Park to foreign visitors as opposed to other national parks of Sarawak is partly due to Proboscis Monkey being promoted as the park's flagship or "iconic" species, besides having a number of other rare species and a diverse array of flora, and being easily accessable and close to Kuching City. Besides offering an opportunity to escape from everyday life through seeking natural park attributes, the uniqueness of destinations has been reported as a primary reason for visitors' travel motives (Kruger & Saayman, 2010; van der Merwe & Saayman, 2008). Interestingly, there has been an increasing number of local visitors accessing the park, especially over the weekends and during school holidays, although they also access other recreational areas such as Semonggoh Wildlife Rehabilitation Centre, Matang Wildlife Centre, and Kubah National Park (Budeng, 2004).

Seasonal variation in visitation is caused by many factors, including income and travel costs (Donovan & Champ, 2009; Morgan, 1986), as well as free time available to the family (school holidays, weekends) as stated above. This variation can have a significant effect on park management because managers need to be aware of and hence cope with and plan for visitor number fluctuations throughout the year (Budeng, 2004). Increased visitation in certain months has been reported to impair the integrity of national parks due to higher use frequency (Obua, 1997), however, this is not the only factor. The types of activities that park visitors engage in also contribute to further deterioration of park attributes (Arrowsmith & Inbakaran, 2002; Buultjens, Ratnayake, Gnanapala, & Aslam, 2005). For Bako National Park, heavy visitation may likely to cause both direct and indirect impacts on the park's flora and fauna. Besides habituation of wildlife, some trails have deteriorated due to erosion resulting from heavy trampling. Some of the impacts have been and continue to be alleviated with necessary mitigation action taken by the park management. Heavy visitation in specific months, particularly July and August, has been a very common phenomenon for Bako National Park. Without the integration of this phenomenon into the park's management strategies, the adverse impact derived from this visitation could not be manageable. Given this, a holistic management approach is clearly very important for the sustainable management of tourism in the park in order to preserve and conserve the park's integrity as a protected area.

7.1.4 Research Objectives

Specifically, the preferred objective of this study is to investigate how visitors on-trail influence the foraging behaviour of Proboscis Monkey.

7.2 METHODS

The aim of this section is to outline the procedure used to collect and analyse data. Details of the preliminary survey and the procedure of data collection for the main study are described. This study was undertaken at Bako National Park only.

7.2.1 Time Schedule

Preliminary observations of trail user activities on-trail were conducted during the months of December 2010 and March 2011. A total of 96 hours of observation over 8 days of field time during this two-month period formed the basis of this preliminary study. The first purpose of these observations was to identify types of activity that trail users performed on-trail. The second purpose was to identify the reaction of Proboscis Monkey in response to the trail users' activities on-trail with the aim of categorising those responses. From this preliminary study, I identified and located the observation sites and designed the field sheets for recording data during the main study (Appendix 14).

The field sheets were designed to record the following information.

a. List of trail users' activities on-trail

   Under this category I identified and listed eight trail users' activities on-trail, namely walking, talking, photographing, pointing, laughing, silent (normally standstill), binocular use and off-trail. The data entered in the field sheets was either "yes" or "no" according to whether the trail users performed the above said activities.

b. Proboscis Monkey's response

Proboscis Monkey's behaviours were identified in other research in conjunction with this research and defined in the earlier chapter in this thesis. Under these broad behavioural categories, the response was recorded either "yes" or "no" according to whether that behaviour was disturbed or interrupted by the trail users' activity on-trail (Griffin et al., 2007).

c. Trail users profile

In this section gender of adults and children, and number of trail users at the entry point were recorded.

The actual field observation for the main study identifying the interaction between trail users' activities on-trail and Proboscis Monkey's behaviour was conducted from June 2011 till May 2012. The continuous twelve-hour field survey was conducted between 6:30 am and 6:30 pm on selected days of each month for this 12 month period. All observations were maintained and grouped within time blocks recorded every fifteen minutes to derive the peak hours trail users entered the entry point. This technique was also utilised to identify the time Proboscis Monkey was present at the entry or observation point. Observations needed to be conducted between 6:30 am and 6:30 pm to secure as much observation as possible of trail user on-trail-Proboscis Monkey encounters at the entry or observation point. Observations were undertaken both on weekdays and during weekends. In total, the survey involved 17 continuous 12 hour day-observations or 204 hours, averaging 1.4 days per month (Table 7.1).

Table 7.1: Field time at study site

# Days	# Hours	#Weekdays	#Weekends
17	204	10	7

7.2.2 Location of Trail Users On-Trail and Proboscis Monkey Observations

The main observation survey of the trail users' on-trail and Proboscis Monkey's behaviour was undertaken at the entry point of Paku Trail, 100 m from Paku Trail-Lintang Trail junction. This trail was identified as a regular Proboscis Monkey foraging site during preliminary surveys for this research study (see Chapter 5). The survey-entry point was a clear, open area which trail users on-trail had to pass to continue on to Paku Beach. About 20 m from the entry point I located a vantage point which was screened by undergrowth. This vantage point was identified during the preliminary field survey. I did not follow trail users along the trail for many reasons, among which were:

a. This research was not targeting specific group or individual trail users on-trail;

b. Paku Trail is more than 600 m long, undulating, crooked and rugged, and following trail users on-trail every hour up and down was not practical;
c. Based on the preliminary survey, Proboscis Monkey was not observable throughout the whole day along the trail;
d. Based on the preliminary survey, the location of the entry point was identified as an area regularly frequented (although not every day) by Proboscis Monkey, and
e. The entry point was an accessible area which was shared (Jens, Mager-Melicharek, & Rietkerk, 2012) between the trail users' walking path and the Proboscis Monkey's foraging path.

As the daily routine of work progressed it was obvious that Proboscis Monkey frequently foraged within or around the entry point. The entry point area was also found to have a clumped distribution of food plants among them from families of Clusiaceae and Myrtaceae which also fell under Habitat 1 as outlined in Chapter 5.

7.2.3 Trail Users' Behaviour On-Trail

Trail users' behaviour on-trail in this research refers to observed activities that trail users engaged in (Budeng, 2004). These activities were identified and categorized during the preliminary survey. Grouping activities under a number of general terms was confusing, therefore I observed and noted each specific activity (Treves &

Brandon, 2005; van Krunkelsven, et al., 1999) and thus avoided recording combinations of activities that happened concurrently. These activities are defined as follows and are in accordance with other research undertaken in the field in Bako National Park (Budeng, 2004; Good, 1988).

a. Walking

   Walking refers to trail users engaging in walking when passing the entry point and occasionally concurrent with talking.

b. Talking

   Talking refers to trail users talking to one another at the observation site.

c. Photographing

   The trail users are considered to be photographing when they are engaging in taking photos.

d. Pointing

   Pointing is raising a hand and fingers to Proboscis Monkey.

e. Laughing

   Laughing refers to trail users engaging in laughing when passing the entry point.

f. Silent

   Silent refers to trail users not speaking or laughing and being at a standstill at the entry point to view Proboscis Monkey.

g. Binocular

   Binocular activity is considered an activity when a trail user uses binoculars to view Proboscis Monkey.

h. Off-trail

Trail users are considered off-trail when they walk away from the trail at the entry point.

7.2.4 Identifying and Selecting Trail Users On-Trail for Observation

I randomly selected a trail user for observation among those present on-trail at the same time, but occasionally chose to observe an on-trail user whose activity first triggered the Proboscis Monkey's response behaviour (Blom et al., 2004; Treves & Brandon, 2005). If the observed trail user became invisible I quickly selected another who remained visible from my vantage point. Observed trail users were therefore, on a number of occasions, interchanged depending on their visibility from my stationary vantage point. The number of trail users present in the vicinity of those animals under observation in each 15 minutes was recorded (Granquist, 2009) and sorted according to gender.

7.2.5 Observation Process

The observation process was conducted in accordance with other research concerning effects of non-consumptive outdoor activities on wildlife (Blanc et al., 2006; Boyle & Samson, 1985; Dyck & Baydack, 2004; Speight, 1973) and techniques of observing visitors' behaviour (Coch, 2002) as there are no previous studies concerning the effects of visitor activities on Proboscis Monkey's foraging behaviour in national parks. Proboscis Monkey's responses were considered to be the effects of trail users' activity on-trail. In particular, the effects were evident if Proboscis Monkey changed it behaviour, stopped foraging and moved away from the observation point to another location (Blanc et al., 2006). On a number of occasions, Proboscis Monkey that moved from the observation point to mangrove forest nearby due to trail user activity were visible from the vantage point. On the other hand, encounters between trail user and Proboscis Monkey were only recorded when I was physically able to observe Proboscis Monkey, either non-responsive to on-trail activity, corresponding as outlined above. Therefore, an encounter occurred only when both trail user and Proboscis Monkey were present at the same time and observable from the vantage point.

The effects of each trail users' activity on Proboscis Monkey's foraging behaviour were recorded from which activity was first encountered (Treves & Brandon, 2005) that caused interruption in monkeys' behaviour at the observation point. If more than one activity was performed concurrently by a trail user, only the more lasting activity was considered to affect Proboscis Monkey's foraging behaviour and recorded as such. I located myself at the single vantage point and recorded both trail users' activity on-trail (Burger & Gochfeld, 1993; Gale & Jacobs, 1987; Schultz & Bailey, 1978; van der Zande, Berkhuizen, van Latesteijn, ter Keurs, & Poppelaars, 1984) and the monkeys' responses to their presence and activities. I continuously monitored Proboscis Monkey's behaviour for effects from trail user activities from the vantage point, recording changes in its behaviour until it disappeared from the vicinity of observation point (Griffin et al., 2007). This was to ensure that only changes in monkeys' behaviour due to visitors' activities on-trail were recorded.

7.2.6 Proboscis Monkey-Response Behaviour

Behaviours of Proboscis Monkey such as feeding, resting, travelling, and others have been described in Chapter 5. These same behaviours were observed and recorded in response to the trail users' activities on-trail. Responses were recorded for each individual animal from which a reaction was clearly observed due to interruption by trail users' activities (Burger & Gochfeld, 1993; McLennan & Hill, 2010). As noted in Chapter 6, Proboscis Monkey's behaviour associated with its routine daily foraging was calm and relaxed. Foraging behaviour patterns were structured and rhythmic, without any sign of alarm or panic. The monkeys also appeared patient and methodical when engaged in foraging activities. When interruptions or disturbances occurred their behaviour changed, with changes varying according to the types of foraging activities they were engaged in. For the purpose of this study Proboscis Monkey's response behaviour was defined as follows.

a. Feeding-response behaviour

   Proboscis Monkey stops feeding totally and moves away or stops feeding for a few seconds but continues again with different modes or rhythm.

b. Resting-response behaviour

   Resting is slightly or totally disturbed when Proboscis Monkey wakes up from resting and changes its resting position and/or runs away from its resting position.

c. Travelling-response behaviour

   Travelling speed and frequency either increases or decreases and becomes unstructured and erratic with different travelling direction and rhythm.

d. Other behaviour-response behaviour

   Proboscis Monkey ceases in engaging in other activities and/or runs away.

7.2.7 Identifying and Selecting Proboscis Monkey for Observation

I selected one Proboscis Monkey randomly from the group of Proboscis Monkey present near the vantage point without selecting for either female or male (Treves & Brandon, 2005). Occasionally, I observed two animals at one time. If the observed Proboscis Monkey disappeared I randomly selected another one that was visible from my vantage point.

7.2.8 Trail Users On-Trail-Proboscis Monkey Encounters

During the observations, an interaction was recorded when there was an encounter (Ballantyne, Packer, Hughes, & Dierking, 2007; McLennan & Hill, 2010) as outlined above. Therefore, interaction occurred between trail users on-trail and

Proboscis Monkey when both were present at the entry or observation point at the same time. It was not taken into account if trail users on-trail were aware or not of the presence of Proboscis Monkey at that time. Proboscis Monkey's responses due to noises or other disturbances that were not derived from trail users' activity on-trail at the entry or observation point were not recorded. In general such noises were absent over the period of study with the exception of engine noise from the tourist boats which were about 200 m away from the observation point. From the preliminary study and as my field work progressed, I observed that Proboscis Monkey appeared to have been habituated to noise from the tourist boats. This apparent habituation is in contrast to studies in Brownsberg Natuur Park, Suriname, where Howler Monkeys (*Alouatta seniculus*) showed less response to or avoidance of disturbing noises (Westin, 2007). Over the whole period of the field survey, I observed 198 encounters and recorded 369 behavioural responses from the effected Proboscis Monkey.

7.2.9 Data Analysis

The Cross-tabulation and chi-square test were used to test for differences in the correlation between trail users' activity on-trail and Proboscis Monkey's response behaviour. The Cochran test was also used to test the related Proboscis Monkey's response behaviour that corresponds to the trail users' activity on-trail. To test for any significant difference between Proboscis Monkey's response and non-response behaviour in relation to the number of trail user on-trail, the Mann-Whitney test was used. Cross-tabulations of feeding activity with the following variables were produced.

1. Walking versus feeding
2. Talking versus feeding
3. Photographing versus feeding
4. Pointing versus feeding
5. Laughing versus feeding
6. Silent and/or Standstill versus feeding
7. Binocular versus feeding
8. Off-trail versus feeding

7.3 RESULTS

7.3.1 Trail User Profile

Over the 17 twelve-hourly-day observation periods of the field survey, a total of 1961 trail users passed the entry point or observation spot at Paku Trail. Therefore, an average of 115 trail users per day, or averaging 2 to 3 persons in 15 minutes passed the entry point (Figure 7.1). The peak of traffic on this trail varied depending on the high tide, which influenced when trail users were able to disembark at the trail entrance. The highest number of trail users in the mornings was recorded between 11:15 am and 11:30 am (average 4 to 5 persons) and in the afternoons between 3:30 pm and 3:45 pm (average 4 to 5 persons). Adult trail users were predominantly female (55 per cent female, 45 per cent male: n=1961).

Children only accounted for 5 per cent of the trail users and were present during 7 of the 17 days of observation (Table 7.2).

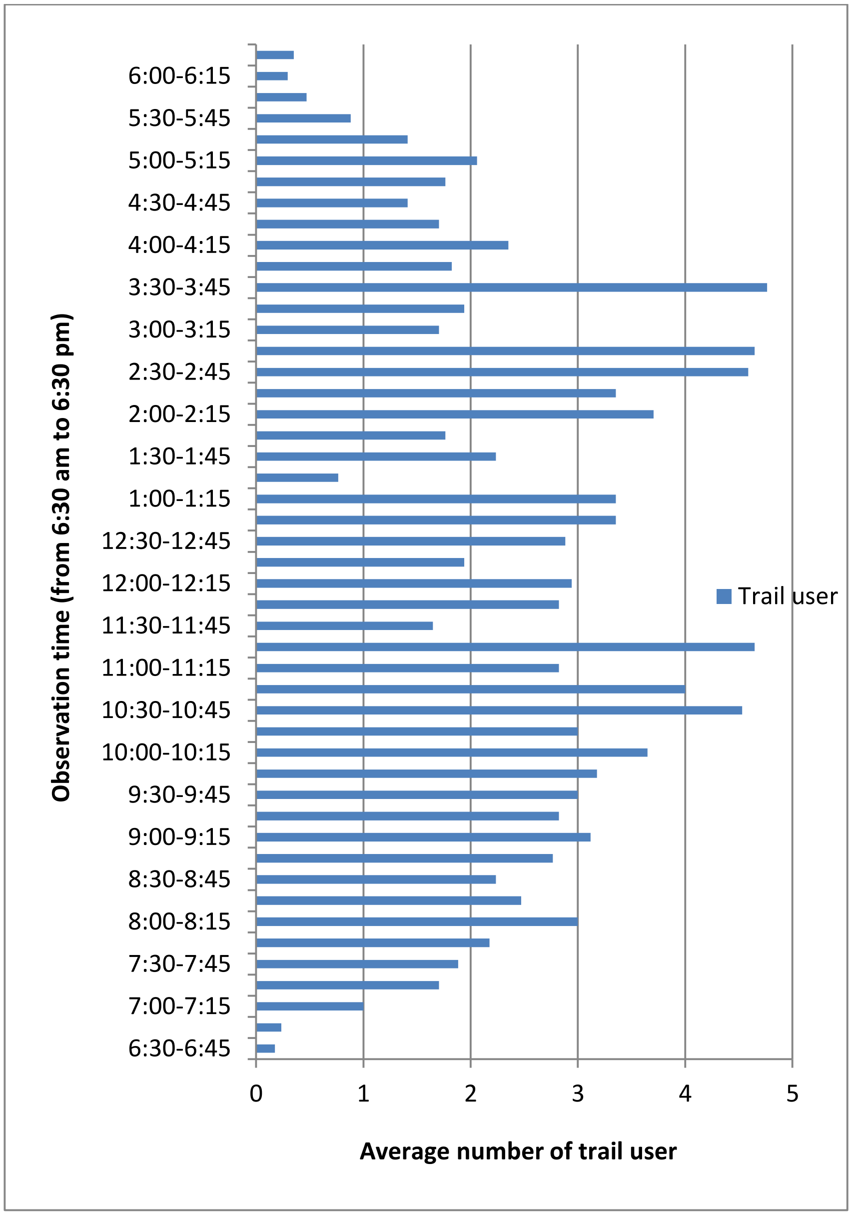


Figure 7.1: Average number of trail users per 15 minutes observed passing the entry point

Table 7.2: Category of trail users during observation from 6:30 am to 6:30 pm (n=1961)

Observation day	No. of trail user		
	Female	Male	Children
1	58	53	
2	113	101	20
3	111	99	19
4	74	60	12
5	67	59	
6	52	41	
7	54	49	
8	38	39	9
9	43	30	13
10	31	35	
11	63	42	
12	56	43	17
13	61	58	
14	73	62	
15	61	36	
16	64	30	5
17	65	40	
Total	1084	877	95

7.3.2 Trail User Activity On-Trail

The activity that the randomly selected and observed trail users were most frequently engaged in was talking, representing 42.2 percent of all activities observed (Table 7.3). Most visitors stayed about 20 minutes at or in the vicinity of the observation spot. Photographing was the second most frequently observed activity (29.4%) performed on-trail during the period of study, followed by walking (20.7%). Silence and/or standing still at the entry point was not frequently observed (4.2%). Pointing to Proboscis Monkey represented 1.3 per cent of the observed activity of trail users, whereas laughing was rarely observed, at 1 per cent. Trail users on-trail also rarely used binoculars, representing just 0.8 per cent of all the activities observed. The least observed activity was off-trail which represented 0.4 per cent of all the activities observed.

Table 7.3: Observed activities while under observation (n=788 activities)

Activity on trail	**Percentage**
Walking in silence	20.7
Talking (either walking or standing still)	42.2
Photographing	29.4
Pointing	1.3
Laughing	1.0
Silent and/or standing still	4.2
Binocular	0.8
Off-trail	0.4
Total	100.0%

7.3.3 Proboscis Monkey's Response Behaviour

During the period of trail user and Proboscis Monkey observations, a total of 198 encounters between the two were recorded, representing 25 per cent of the total trail users' activities observed on-trail for the study period. During these encounters, 359 specific activities performed by trail users were recorded. These activities triggered 369 Proboscis Monkey responses (Table 7.4) within the following behavioural response categories: feeding-response behaviour (188 = 51%), resting-response behaviour (143 = 39%), travelling-response behaviour (10 = 3%), and other behaviour-response behaviour (28 = 7%). Clearly the most frequently observed response to these encounters were those related to feeding which suggest that feeding behaviour was most effected by encounters between Proboscis Monkey and trail users.

Table 7.4: Number of trail user (TU) activities, trail user-Proboscis Monkey (TU-PM) encounters, and Proboscis Monkey (PM) responses at the survey entry point

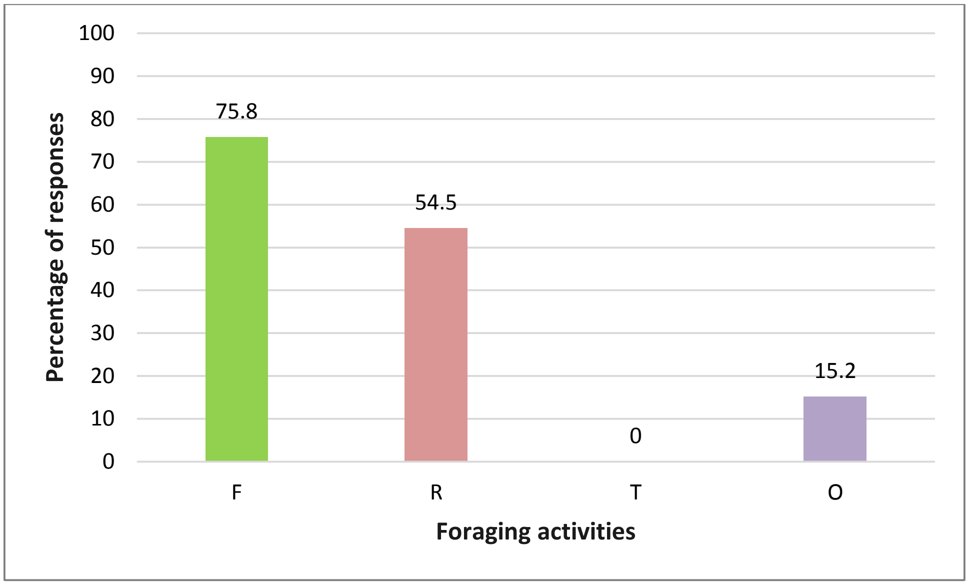
Observation Day	No. of TU activities	No. of TU-PM encounters	No. of PM responses			
			Feeding	Resting	Travelling	Others
1	12	7	5	2	1	0
2	23	12	6	10	5	0
3	19	12	11	4	0	3
4	14	9	6	1	1	1
5	24	11	14	9	1	1
6	20	10	13	4	0	0
7	21	13	12	6	0	0
8	14	9	11	9	0	8
9	26	14	8	15	0	0
10	20	12	10	6	0	0
11	29	17	14	9	0	0
12	30	16	14	19	0	4
13	25	13	14	15	0	4
14	19	11	8	6	2	2
15	23	15	10	8	0	1
16	23	9	20	12	0	3
17	17	8	12	8	0	1
Total	359	198	188	143	10	28

7.3.4 Movement-Related Activities

Walking

Proboscis Monkey's feeding behaviour was interrupted on 25 occasions due to TUs walking in the vicinity of those animals under observation. In other words 13.3 per cent (n = 188) of all feeding-related responses (i.e. interruption of feeding), were due to TUs walking. Of all the walking activities that triggered the Proboscis Monkey responses, feeding was the most frequently interrupted, accounting for 75.8 per cent (n = 33) (Figure 7.2). This was followed by disturbance to resting which accounted for 54.5 per cent, and other behaviours at 15.2 per cent. Travelling was not interrupted. However, not all activities the animals engaged in were disturbed due to TUs walking, as often they continued on without interruption, showing clearly a non-response to TUs walking. Of these, 24.2 per cent of feeding activity (n = 33) was identified as a non-response (continuation of feeding as normal), 45.8 per cent of resting was not interrupted, 84.8 per cent of other behaviours were not disturbed, and 100 per cent of travelling was not interrupted.

A significant difference was evident in the occurrence of interrupted feeding activity in relation to TUs walking ($n=198$; $X^2 = 143.06$, d.f. 1, $p < 0.001$). TUs walking had caused similar effects on Proboscis Monkey's foraging activities in corresponding to their response behaviours ($p< 0.001$) suggesting no statistically different effect although they responded differently. There was a highly significant difference between response and non-response behaviours of Proboscis Monkey according to the number of TUs walking ($n=198$; $Z = -12.23$, $p < 0.001$).



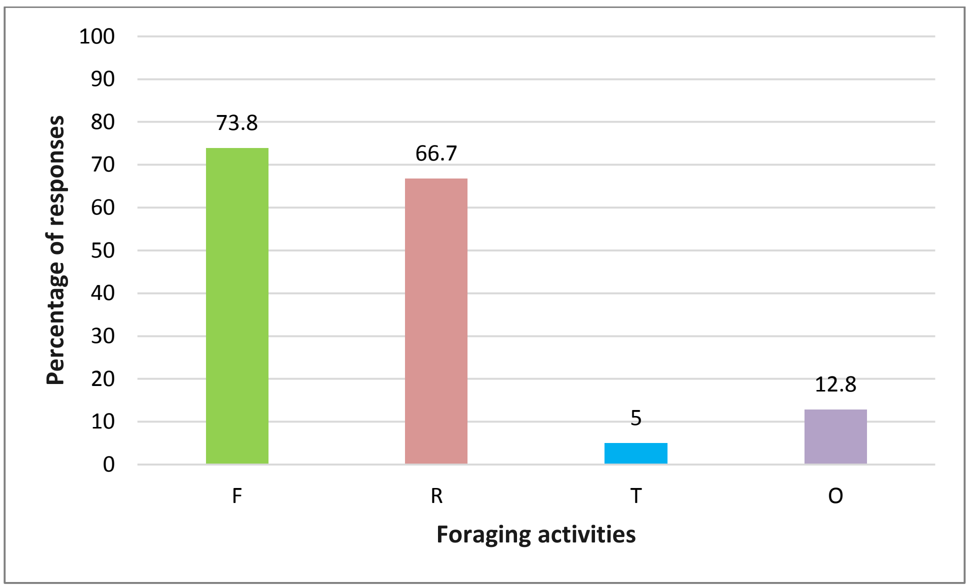
F-feeding, R-resting, T-travelling, O-other activities

Figure 7.2: Response behaviour in association with walking

Talking

There were 104 occasions observed of Proboscis Monkey's feeding behaviour being interrupted when TUs engaged in talking whilst walking or viewing Proboscis Monkey under observation. Of all the feeding-related responses (n = 188), the interruption of feeding due to TUs talking was 55.3 per cent. Feeding behaviour was the most frequently interrupted, accounting for 73.8 per cent of all the TU talking activities (Figure 7.3) that triggered the monkey responses (n = 141). The interruption to resting accounted for 66.7 per cent, with travelling accounting for 5 per cent, and other behaviours 12.8 per cent. Proboscis Monkey also showed non-response behaviours to TUs talking, accounting for 26.2 per cent of the feeding activity (n = 141) identified as a non-response, 33.3 per cent of resting not interrupted, 95 per cent of travelling and 87.2 per cent of other behaviours not disturbed.

The occasions of disturbed Proboscis Monkey's feeding activity in relation to TUs talking was highly significant (n = 198; X^2 = 88.56, d.f. 1, $p < 0.001$). Proboscis Monkey showed no different responses when its foraging activities were affected by TUs talking ($p<0.001$) suggesting that TUs talking triggered no different effects on foraging behaviours. A highly significant difference existed between response and non-response behaviours according to the number of TUs talking (n=198; Z = -9.8, $p < 0.001$).



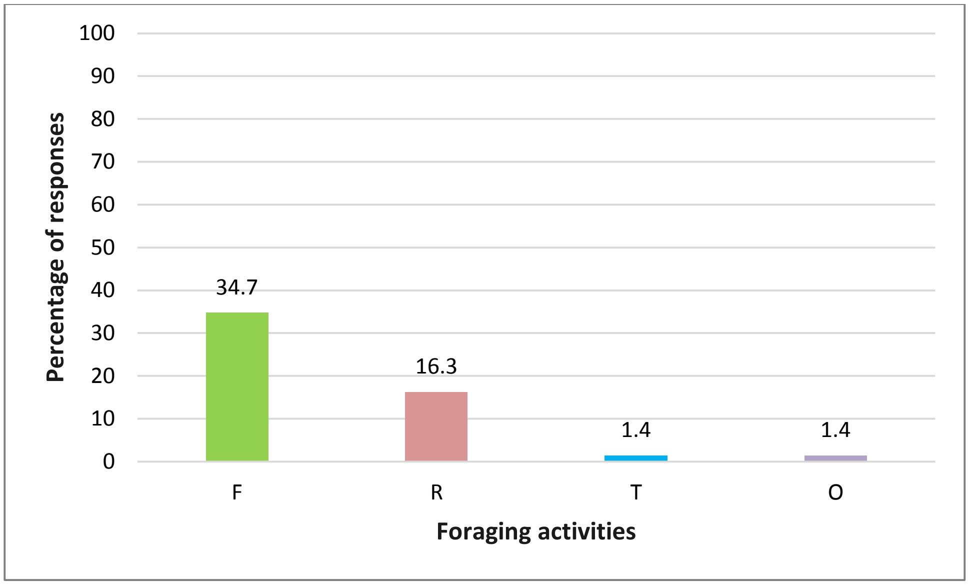
F-feeding, R-resting, T-travelling, O-other activities

Figure 7.3: Response behaviour in association with talking

Photography

Proboscis Monkey's feeding behaviour was interrupted on 51 occasions due to TUs photographing in the vicinity of those animals under observation. Of all the feeding-related responses, the interruption of feeding due to TUs photographing accounted for 27.1 per cent (n = 188). Feeding was the most frequently interrupted behaviour, accounting for 34.7 per cent (n = 147) of all the TU photographing activities that triggered Proboscis Monkey responses (Figure 7.4). This was followed by disturbance to resting which accounted for 16.3 per cent, travelling which accounted for 1.4 per cent, and other behaviours which accounted for 1.4 per cent. As not all activities the animals engaged in were disturbed due to TUs photographing, they often continued on without interruption, showing clearly a non-response to TUs photographing. Of these, 65.3 per cent of the feeding activity (n = 147) was identified as a non-response, with 83.7 per cent of resting not interrupted, 98.6 per cent of travelling not disturbed and 98.6 per cent of other behaviours not disturbed.

The occurrence of Proboscis Monkey's feeding interrupted in relation to TUs photographing was statistically significant (n = 198; $X^2 = 23.83$, d.f. 1, $p = 0.001$). Proboscis Monkey showed no different responses when its foraging activities were affected by TUs photographing ($p<0.001$) suggesting that TUs photographing triggered no different effects on foraging behaviours. Furthermore, there was a highly significant difference between response and non-response behaviours in relation to TUs photographing (n=198; $Z = -8.9$, $p < 0.001$).



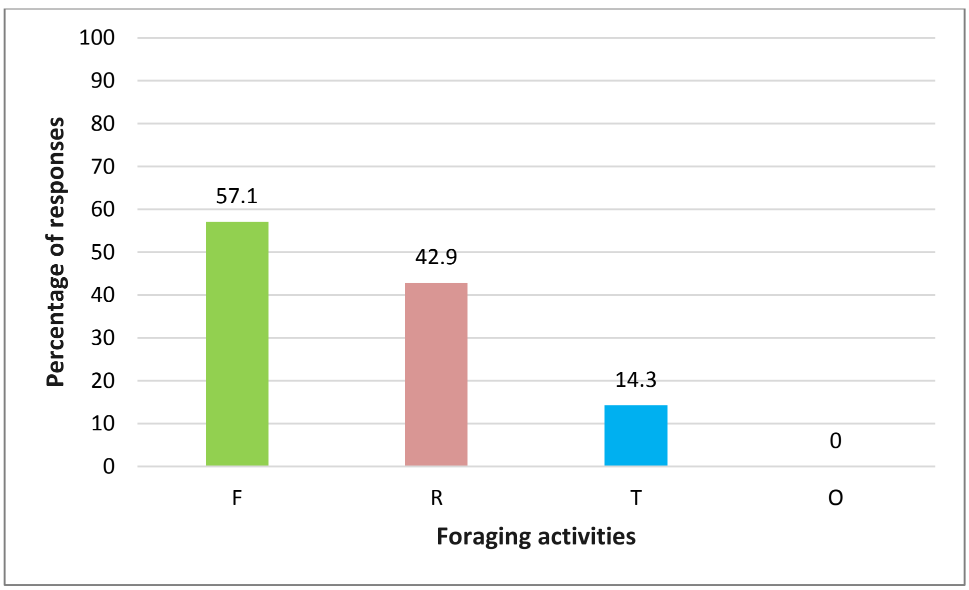
F-feeding, R-resting, T-travelling, O-other activities

Figure 7.4: Response behaviour in association with photography

Pointing

There were four occasions of interruption to feeding activity due to TUs pointing in the vicinity of those animals under observation. These occasions accounted for 2.1 per cent of all the feeding-related responses (n = 188). In addition, feeding was the most frequently interrupted behaviour, accounting for 57.1 per cent (n = 7) of all the TU pointing activities that triggered Proboscis Monkey responses (Figure 7.5). This was followed by disturbance to resting which accounted for 42.9 per cent, and travelling which accounted for 14.3 per cent. Other behaviours were not interrupted. However, not all activities the animals engaged in were disturbed due to TUs pointing, as often they continued on without interruption, showing clearly a non-response to TU pointing. Of these, 42.9 per cent of the feeding activity (n = 7) was identified as a non-response, 57.1 per cent as resting not interrupted and 85.7 per cent as travelling not interrupted.

A highly significant difference existed in the occasions of interrupted feeding in relation to TUs pointing (n=198; X^2 = 111.39, d.f. 1, $p < 0.001$). Proboscis Monkey showed different responses when it foraging activities were affected by TUs pointing ($p > 0.05$) suggesting that TUs pointing triggered different effects on foraging behaviours. There was a highly significant difference between Proboscis Monkey's response and non-response behaviours in relation to TUs pointing (n = 198; Z = -10.5, $p < 0.001$)



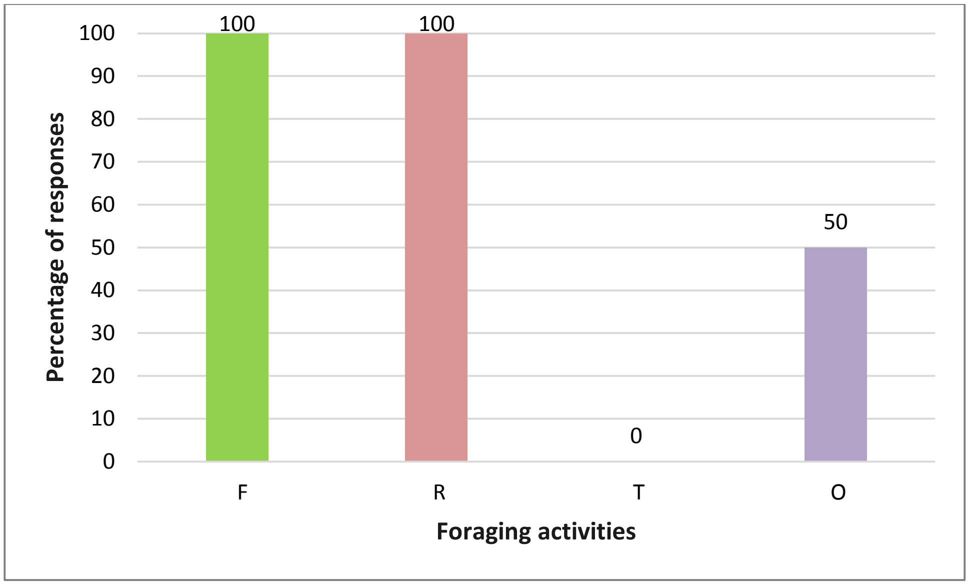
F-feeding, R-resting, T-travelling, O-other activities

Figure 7.5: Response behaviour in association with pointing

Laughing

There were two occasions where feeding activity was interrupted due to TUs laughing in the vicinity of those animals under observation. These occasions represented 1.1 per cent (n = 188) of all the feeding-related responses. TUs laughing seriously affected foraging behaviours of Proboscis Monkey in that feeding and resting were the most frequently interrupted, with both accounting for 100 per cent (n = 2) respectively (Figure 7.6). While travelling was not interrupted, other behaviours displayed 50 per cent disturbance due to laughing. However, Proboscis Monkey showed non-response behaviour to TUs laughing in travelling and other behaviours, but not in feeding and resting, as often they continued with travelling and other behaviours without interruption which accounted for 100 per cent and 50 per cent (n = 2).

The occasions of feeding behaviour being disturbed in relation to TUs laughing was highly significant (n=198; $X^2 = 198$, d.f. 1, $p < 0.001$). TUs laughing had caused adverse effects on Proboscis Monkey's foraging activities which triggered different response behaviours ($p>0.05$). A highly significant difference existed between response and non-response behaviours in relation to TUs laughing (n = 198; Z = -14, $p< 0.001$).



F-feeding, R-resting, T-travelling, O-other activities

Figure 7.6: Response behaviour in association with laughing

Silent

TUs were observed as being silent on 26 occasions in the vicinity of those animals under observation. However, this TU activity had no effect on Proboscis Monkey's feeding activity, such that no response behaviour occurred in correlation with TUs remaining silent. Proboscis Monkey under observation continued on foraging without interruption. Therefore, no measure of association was computed for cross-tabulation of TUs being silent and Proboscis Monkey's foraging behaviours.

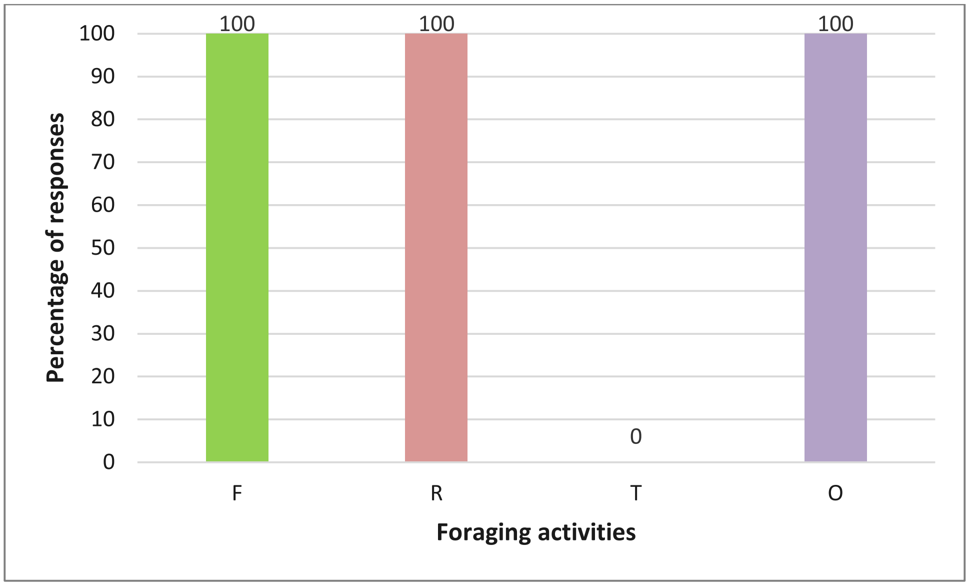
Binocular

Of all TU activities observed in the vicinity of those animals under observation, only one occasion was observed where a TU used a binocular for viewing. This activity had no effect on Proboscis Monkey's foraging behaviours such that no response behaviour was observed. Therefore, no measure of association was computed for cross-tabulation of TU using a binocular and Proboscis Monkey's foraging behaviours.

Off-trail

Proboscis Monkey's feeding activity was interrupted on two occasions due to off-trail activity in the vicinity of those animals under observation. These occasions of interruptions accounted for 1.1 per cent (n = 188) of all the feeding-related responses. The off-trail activity seriously affected foraging behaviours of Proboscis Monkey under observation, especially feeding, resting and other behaviours which accounted for 100 per cent (n = 2) respectively (Figure 7.7). This explains that no non-response behaviour was identified in these foraging activities. Conversely, travelling was not interrupted by the off-trail activity, suggesting 100 per cent non-response to this activity.

The occasions where Proboscis Monkey's feeding activity was adversely disturbed in relation to the off-trail activity were highly significant (n=198; $X^2 = 198$, d.f. 1, $p < 0.001$). However, the off-trail activity had no equal effects on the Proboscis Monkey's foraging activities in correlation to their response behaviours ($p>0.05$). This explains that statistically, foraging behaviours were affected differently due to the off-trail activity although interruptions of feeding, resting and other behaviours were similar. Furthermore, a highly significant difference existed between response and non-response behaviours according to the off-trail activity (n = 198; Z = -14, $p < 0.001$).



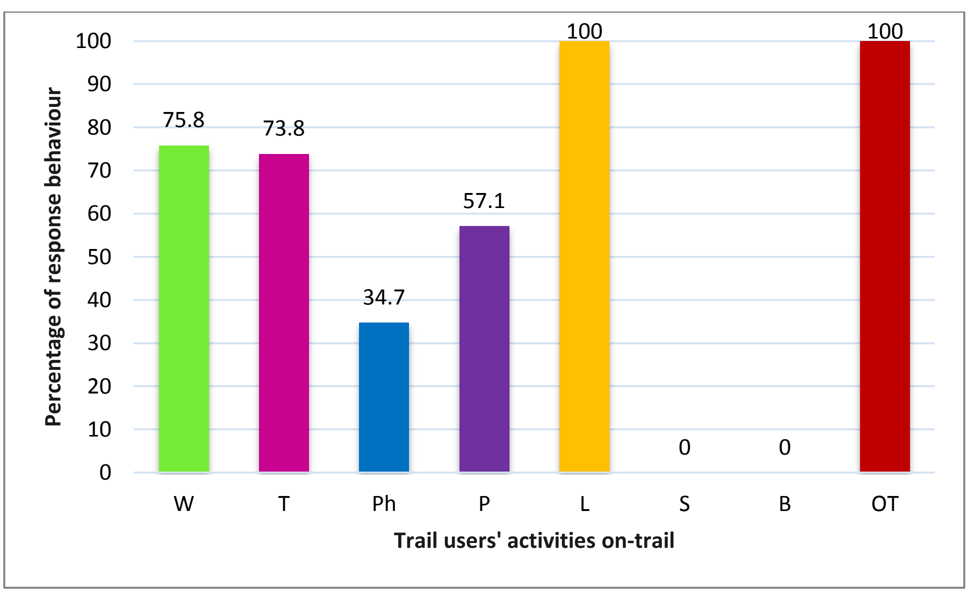
F-feeding, R-resting, T-travelling, O-other activities

Figure 7.7: Response behaviour in association with off-trail activity

7.3.5 Feeding-Response Behaviour

Proboscis Monkey's feeding-response behaviours differed in relation to TUs' activities in the vicinity of those animals under observation. Of these TUs' activities, laughing and off-trail triggered 100 per cent of the feeding-response behaviour (Figure 7.8). Although laughing and off-trail activities only represented 1.0 and 0.4 per cent of all the TUs' observed activities (Table 7.4), they caused the most adverse effects on the Proboscis Monkey's feeding activity. Walking caused 75.8 per cent of Proboscis Monkey's feeding-response behaviour, which was 2.0 per cent higher than talking (73.8%). On a number of occasions, TUs under observation had to walk to obtain close contact with Proboscis Monkey before taking photographs. On the other hand, TUs who engaged in talking sometimes did not realize there was Proboscis Monkey in the trees in the vicinity of the entry point.

TUs that engaged in pointing at Proboscis Monkey triggered 57.1 per cent of feeding-response behaviour which was higher than the 34.7 per cent of feeding-response behaviour due to TUs photographing. Referring to Table 7.4, photographing accounted for 29.4 per cent of all the TUs' observed activities, as opposed to pointing (1.3%) and walking (20.7%). Conversely, TUs who kept silent and standstill and engaged in binocular activity had no effect on Proboscis Monkey's feeding behaviour, such that no feeding-response behaviour was triggered in relation to these TUs' observed activities.



W-walking, T-talking, Ph-photographing, P-pointing, L-laughing, S-silent, B-binocular, OT-off-trail

Figure 7.8: Proboscis Monkey's feeding-response behaviour

7.4 DISCUSSION

7.4.1 Trail User Profile

Trail users of Paku Trail were slightly skewed with regard to gender with more females (55%) than males (45%) using the trail. This finding contrasts with a previous study in Bako National Park (Budeng, 2004) and similar studies in other parks (Kellert & Berry, 1987; Ramsay, 1995), which found a lower proportion of females involved in such wilderness activities. This may be due to the focus in this study on the specific trail user on-trail rather than on overall visitation to the park. Paku Trail is one of the short access trails in Bako National Park, and as such is easy to explore and not time consuming, with diverse flora and easy-to-sight Proboscis Monkey and other wildlife. However, opportunities to view Proboscis Monkey on Paku Trail are dependent on time and other factors such as rain, crowding and visitor activities on-trail (Budeng, 2004). The strategic location of Paku Trail, which is near to the boardwalk through mangrove forests at Teluk Assam, also appears to attract all age categories of visitors including children, younger and older visitors. It could be used as a loop route that provides an option to visitors who walk on the trail and return to the park headquarters by tourist boats.

More females than males at this site may also be explained by those studies which found that females were predominantly more interested in wildlife tourism destinations (Ballantyne et al., 2011), with more females tourists involved in wildlife viewing than males in such natural settings (Pearce & Wilson, 1995). Although sighting for Proboscis Monkey may not be the main objective for visiting Bako National Park, for visitors who do not want to stay overnight in the park, Paku Trail provides an ideal venue for day-trippers to enjoy sighting for the monkeys. This may also explain the slightly higher number of females on Paku Trail as female visitors are more inclined to be day-trippers (Budeng, 2004).

7.4.2 Effect of Trail Users' Activities On-Trail

Trail users' activities on-trail have been reported to adversely affect biophysical features of the natural setting, including vegetation, soil, water, and wildlife resources (Farrell & Marion, 2001). However, the impact of trail users' activities on wildlife is also significant and corresponds to the types of activities engaged in and distances the trail users are from the wildlife. Such impacts have been reported by many researchers including de la Torre, Snowdon and Bejarano (2000); Griffiths and van Schaik (1993); Grossberg, Treves and Naughton-Treves (2003); Johns (1996); and Werdenich et al. (2003).

This study has found that in Bako National Park, if not properly managed (of visitor impacts) and guided (especially guided walk by trained naturalist), nature-based tourism (that includes sighting for wildlife, especially Proboscis Monkey) can adversely affect wildlife foraging behaviour, and feeding and resting behaviour in particular. Also of concern is the capacity for close contact between visitors and wildlife, which can also lead to wildlife becoming habituated. Even though Paku Trail is a popular site for wildlife sighting, especially Proboscis Monkey, often trail users did not realize there was Proboscis Monkey in trees above them at the entry point, instead often continuing to engage in talking. Once realised, they would tell others of the presence of Proboscis Monkey in the vicinity. Talking was the most frequent activity trail users engaged in (n = 333; 42.2%). The higher percentage of TUs talking on Paku Trail as opposed to other TUs' activities may be partly due to the higher number of day-trippers accessing this trail. A previous study in the park confirmed that the majority of trail users on Paku Trail were day-trippers who were often less concerned with the impact of their activities on Proboscis Monkey's foraging behavior (Budeng, 2004). Day-trippers tend to make full use of their time while in Bako National Park and Paku Trail is always the main targeted location for them to enjoy their trip to the park, as opposed to overnight visitors who have more time and have planned to fulfil their different priorities of visiting a number of locations in the park (Budeng, 2004).

The increasing number of trail users at the entry point did not affect Proboscis Monkey's foraging behaviour as they kept silent but the increasing number of talking trail users seriously affected Proboscis Monkey, forcing them to move away from the vicinity of the observation point. In another study, Cassirer et al. (1992) found that the increasing intensity of use on-trail does not increase the negative impact on wildlife as long as trail users keep on following the same trail. The tendency to engage more in talking while walking or viewing Proboscis Monkey occurred when trail users were in a large group. Although not all, some guided tours accessing Paku Trail involved an interpretive talk at the entry point, which is important in nature-based tourism with a wildlife component so as to inculcate better understanding and knowledge about protecting wildlife. The talking trail users were not propotional to the photographing trail users because in most cases not all trail users brought cameras with them. Likewise, while trail users engaged in photographing, they were not always engaged in talking at the same time.

Photographing Proboscis Monkey was the second highest activity observed on-trail (n = 231; 29.4%); a challenging but predominantly silent and stationary activity that trail-users preformed on Paku Trail once the animals were sighted. This activity most often excluded talking and walking, although occasionally they were observed to walk closer to Proboscis Monkey in pursuit of a better photo. The entry point was a strategic location to photograph Proboscis Monkey and so if the monkey was present this is where they were photographed. Moreover, Proboscis Monkey on Paku Trail were observed to be less habituated than Proboscis Monkey in the park headquarters (pers. obs.) and as such there was less opportunity to view and photograph the monkeys on the trail as a result of the infrequency of trail user-Proboscis Monkey encounters. According to Boyle and Samson (1985) photographing wildlife has been a popular non-consumptive activity in natural settings. However, they found photographing activity is potentially more disturbing to wildlife because encounters are likely to be more frequent and of longer duration. Given the situation on Paku Trail, although trail users walked closer to better view Proboscis Monkey, they could not come close enough to inflict direct impact because Proboscis Monkey was positioned high in the tree canopy. In a number of cases, they photographed Proboscis Monkey at a distance that was well out of direct impact range. Although some trail users went out of their way to approach the monkeys, most stayed at the entry point to photograph them. However, on a number of occasions trail users undertook prolonged vigils, with photographing Proboscis Monkey therefore responsible for interrupting feeding on 51 occasions, accounting for 27 per cent of the feeding-related responses (n = 188), and resting on 24 occasions, accounting for 17 per cent of the resting-related responses (n = 143). Whilst less disturbing to feeding and resting activities than talking, the disturbance associated with photographing animals is not insignificant, given feeding together with resting are important life sustaining activities for an animal of this size and energy requirements. Such a finding reflects that found by Green and Higginbottom (2000).

Regulations associated with photographing rare and endangered species would assist in conserving and protecting the species and ensuring its long-term survival. This has not been done in Bako National Park, and it is recommended that the park management seek to identify and implement measures to minimize the impact of photographing activity. The management of Bako National Park does not impose fees for photographing activities, except professional filming. Photographing Proboscis Monkey has been a common activity in the park; for example, in every group of 10 trail users that entered the entry point, 7 to 8 trail users brought cameras with them (pers. obs. this study; Budeng (2004)). Besides the growing interests of tourists in wildlife photography, the activity is also used to promote tours and travel agencies focusing on wildlife tourism. While tourists may have a strong urge to view rare and endangered wildlife species in their natural setting, they may also not wish to lose the opportunity to photograph the targeted species once they arrive at the tourist destination. This often once-in-a-lifetime opportunity to photograph rare and endangered wildlife species subsequently outweighs their consideration of the impact they may cause (Green & Higginbottom, 2001). Proboscis Monkey had been only slightly habituated to trail users photographing compared to other activities, with the exception of silent and binocular*.* The individual monkeys (especially adults and juveniles) sometimes did not respond to trail users photographing them except if they were in a group foraging together. On the other hand, not all trail users equipped with cameras had the opportunity to photograph Proboscis Monkey on Paku Trail. In a number of observed incidents trail users with cameras passed the entry point without photographing because they did not realize there was Proboscis Monkey in the trees*.* This explains the lesser impact of photographing in comparison to walking and talking.

Two categories of trail users walking on-trail on Paku Trail were indentified. Firstly, a number of these walking trail users just passed the entry point and continued along the trail even though they were aware of Proboscis Monkey in the trees. A second category of walking trail users slowed down their walking pace when they encountered Proboscis Monkey in the tree canopy. It seemed that they inadvertently encountered Proboscis Monkey as they enjoyed walking on-trail. Therefore, most of the walking impact on Proboscis Monkey occurred incidentally. In a few incidents Proboscis Monkey moved away from the observation point due to the effects of trail users walking on-trail. The impact was more disturbing to the monkeys if trail users comprised a large group of more than five people. As demonstrated by Griffiths and van Schaik (1993), some large animals change their activity patterns and move out of areas of heavy human disturbances. In Bako National Park (in particular Paku Trail), trail users activities, especially walking may also cause changes in Proboscis Monkey's daily-activity patterns, as walking activity has been observed to disturb Proboscis Monkey's foraging behaviours. Large groups of walking trail users on Paku Trail were always accompanied by tourist guides. However, there were a number of incidents in which a large group of walking trail users without a tourist guide passed the entry point. Both of these types of walking trail users adversely affected the foraging behaviour of Proboscis Monkey. Proboscis Monkey did not flee immediately however they gradually moved away from the entry point. This reaction is similar to the behaviour of chimpanzees

(*Pan troglodytes*) that were found to respond to both trail users walking or standing, as documented by Werdenich et al. (2003).

However, in different natural settings with different types of disturbance, wildlife species may vary in their response to similar trail users' activities on-trail. For example, south-eastern Cameroon chimpanzees (*Pan troglodytes*) display more curiosity, whilst gorillas (*Gorilla gorilla gorilla*) usually flee immediately in response to a similar type of human disturbance (Werdenich et al., 2003). Likewise, there may be many unexpected factors that translate to the same wildlife species responding in different ways to the same activities on-trail across different periods of time. On Paku Trail, it was unsurprising that pointing activity on-trail had a greater effect on Proboscis Monkey than photographing. Trail users would tend to tell other members in a group of the presence of Proboscis Monkey by pointing. Pointing disturbed Proboscis Monkey's foraging behaviour because it involved body movements such as raising hand and finger toward the monkeys. In comparison, most trail users who took photographs of Proboscis Monkey did not make such obvious movements. This level of disturbance was in contrast to trail users who kept silent or stayed at a standstill and used binoculars. Besides the limited number of trail users engaged in these activities, they also carried the activities out in a peaceful and quite manner that was not disturbing to the foraging activities of Proboscis Monkey. Viewing Proboscis Monkey using binoculars did not require that trail users come closer to wildlife, and could be undertaken at any direction or distance from any Proboscis Monkey they encountered at the entry point. The nature of both silent and binocular activities that trail users engaged in on-trail therefore manifested the non-response behaviour of Proboscis Monkey.

In contrast, laughing and off-trail which were minor activities that trail users engaged in on Paku Trail inflicted a more adverse effect on Proboscis Monkey. A previous study of wildlife confirmed that trail users' behaviour on-trail caused serious displacement of wildlife from trail (Griffin et al., 2007). In this study Proboscis Monkey moved away from the observation point due to the trail users' activities, especially laughing and off-trail*.* But the direction of movement was dependent on their position in the canopy when the disturbance occurred. On a number of occasions, they moved to the mangrove forests due to trail users' activities, which could be considered a fairly serious displacement from their original location. Laughing and off-trail activities should not be undertaken in natural wildlife settings such as Paku Trail. The park management does not have any regulations in place to limit or prevent these activities. Trail users who engaged in laughing may not have been aware of the consequences of this activity on the animals. Laughing would most likely have been generated by the physical appearance of the animals, the male in particular. Most trail users who engaged in this activity were young people or school children in large numbers or groups. Besides their higher pitchtone, their voices were also louder than the typical talking that trail users engaged in on-trail, which had already been observed disturbing foraging activities of Proboscis Monkey. de la Torre et al. (2000) found that high noise levels have caused lower reproductive success in Pygmy Marmosets (*Cebuella pygmaea*) in areas of heavy tourism activity. Despite this, access to Paku Trail has not had any limitations placed on visitor numbers, and subsequently there is no level of use considerations.

The impact of off-trail activity was also found to be seriously disturbing to Proboscis Monkey's foraging activities, regardless of the number of trail users engaged in it. Because the off-trail activity was engaged in regardless of whether trails users realized the presence of Proboscis Monkey in the trees or not, both incidental and non-incidental contact with Proboscis Monkey through the off-trail activity had some adverse impacts on foraging behaviour. Taylor and Knight (2003) found off-trail activity is more disturbing to wildlife than other activities. They suggested that displacement of wildlife from trails due to off-trail activity is too great compared to other activities on-trail. However, at the Kanyancu tourist station in Uganda, off-trail activity is permitted for trail users to obtain close contact with the Eastern Chimpanzee (*Pan troglodytes schweinfurthi*) and other wildlife, resulting in increased habituation (Johns, 1996). While some primates respond differently to off-trail activity (Werdenich et al., 2003), engaging in this activity with habituated primates would make wildlife viewing more interesting. Given the situation in Bako National Park (in particular Paku Trail), the park management should consider regulating off-trail activity, especially during the peak period for visitation to the park. Unregulated off-trail activity may have more disturbing effect on the monkeys. This was evident in a few cases when tour guides engaged in off-trail activity, which resulted in their actions denying Proboscis Monkey's access to mangroves forests, and also interfering with the opportunities of other trail users sighting for this animal. A similar case has been reported by Dunstone and O'Sullivan (1996) where tourist activities have hindered primates' access to important food resources.

7.4.3 Proboscis Monkey's Response Behaviour

Proboscis Monkey responded to all trail users' activities on-trail except silent and binocular activity. Disturbance to Proboscis Monkey was manifested by their response behaviours to trail users' activities. Proboscis Monkey's feeding activity was mostly affected, as shown by the highest feeding-response behaviour to laughing and off-trail activities. Although the monkeys have been slightly habituated, they were still sensitive to trail users' activities on-trail. This finding is consistent with others; for instance, McLennan and Hill (2010), Berman, Li, Ogawa, Ionica, and Yin (2007), Blom, Cipolletta, Brunsting, and Prins (2004), and Lippold (1990), who have documented that primates are sensitive to human disturbance, especially hiking activities. In most incidents, the monkeys on Paku Trail were engaging in feeding activities and seemed unaware of trail users approaching them. Sudden approaches were highly disturbing to the monkeys and caused them to move away from the vicinity of the observation point.

However, they fled in a dispersed fashion reuniting in another foraging spot in trees visible from my vantage point, 5 minutes after disturbance. Their dispersal-reuniting time frame may be longer if disturbance continued in close vicinity of their foraging spot. This behaviour appears common as demonstrated in other research on primates, for example Treves and Brandon (2005). When engaging in other activities such as travelling, Proboscis Monkey seemed more alert and prepared to respond to trail users' activities on-trail. On the other hand, Proboscis Monkey appeared semi-alert or not at all attentive to trail users' activities on-trail when engaged in resting. This may explain why the feeding-response behaviour was higher than other-response behaviours.

The presence of tourists and their associated activities not only causes stress to primates (de la Torre et al., 2000; Kinnaird & O'Brien, 1996; Westin, 2007) but also abrupt changes in primates' foraging behaviours (de la Torre et al., 2000; Kinnaird & O'Brien, 1996). For example, chimpanzees (*Pan troglodytes schweinfurthi*) are not only responsive to activities on-trail but also to the number of trail users on-trail (Johns, 1996). Moreover, chimpanzees became habituated to the presence of observers after a number of days during a gathering at fruiting fig trees (Johns & Skorupa, 1987). In mangrove forests at Teluk Assam, Proboscis Monkey was also becoming habituated to trail users present on the boardwalk, partly due to the lack of other mangrove forests where no tourists were present.

This suggests their feeding activity may not be adversely affected by trail user present on the boardwalk. Proboscis Monkey on Paku Trail however, may not fully habituate to trail users' activities on-trail, suggesting that its feeding activities has been adversely affected.

On another occasion, Proboscis Monkey stopped feeding and jumped to another tree for a period of time due to trail users' activities on-trail. However, it immediately resumed feeding again in different trees which were visible from my vantage point, but with different rates of feeding and changes in feeding rhythms. This type of primate's response behaviour has been observed by Green and Higginbottom (2001) in a heavily-visited area. However, the distance between trail users on-trail and Proboscis Monkey in trees may also suggest some differences in their feeding-response behaviour. At the entry point on Paku Trail the average height of trees where Proboscis Monkey engaged in feeding was 15 m. However the actual distance between trail user on-trail and the monkey in trees was not established in this study. There may well be an optimal distance between Proboscis Monkey in the canopy and trail user on-trail that would not create any disturbance to them. Distance between primates and humans which influence the primates' response behaviour has been recognized for some time; for example Knight (2010), McLennan and Hill (2010), Treves and Brandon, (2005), van Krunkelsven et al. (1999), who have inferred that primates' foraging behaviour is seriously affected when human activity is in closer proximity to primates' position in trees.

The adversed effect of the trail user on-trail on feeding activity may partly due to Proboscis Monkey engaged in more feeding (see chapter 5) when the encounters occurred. While the changes in feeding-response behaviour are due to the number of trail users and the types of activities on-trail, the types of food sources being accessed during the disturbance event may also be influencial. In another incidental observation, the monkeys showed passive feeding-response behaviour when they fed on fruiting trees. A previous study demonstrated that feeding ecology of leaf-and-fruit-eating primates was influenced by the phenology of food plants (Son & Zoo, 2004; Watts, 2012). Most food resources eaten by Proboscis Monkey at the entry point were young leaves. They could simply jump from tree to tree to feed on young leaves of food plants when disturbed by the trail users' activity on-trail. Having said this, they have options of food plants to feed on.

Given the situation on Paku Trail, where Proboscis Monkey's feeding-response behaviour was found to be triggered by all types of activities on-trail, it is clear that they are not yet habituated to these activities. Proboscis Monkey is very selective in diet and it mostly eats young leaves and a number of fruits from certain plants (Chapter 6) which are out of human reach. In addition, they always foraged in the upper canopy (see chapter 6) as such they are very hard to be habituated in a natural setting such as Bako National Park. Long-tailed Macaque has been noted as more habituated than Proboscis Monkey, however such habituation may have negative impacts on visitors' peaceful enjoyment of their natural settings. On a number of occasions they have been observed approaching visitors and even acting aggressively to gain access to human food. In the past there were a number of incidents recorded of visitors being attacked by Long-tail Macaques at the park headquarters, as a result of visitors being unaware that hiding food underneath their clothes could attract this monkey. Although habituated wildlife in natural settings could potentially improve the wildlife tourism experience in parks, it is clear that this would also bring long-term negative impacts to both wildlife species and the reputation of wildlife tourism.

Proboscis Monkey's feeding-response behaviour on Paku Trail indicated that this animal was very sensitive to human activities. Unlike in Labuk Bay Sabah, Malaysia, where Proboscis Monkey is being provisioned become habituated to the presence of humans and eat human food. This has been a common approach in wildlife tourism to enhance wildlife visibility for tourists (Knight, 2010), however some tourists did not enjoy viewing habituated Proboscis Monkey that has been provisioned. Long-term behaviour modifications through habituation approaches was reported to have negative impacts on the feeding ecology of primates in natural settings (Pathare et al., 2012) and may draw more negative impacts in relation to visitor-wildlife interactions (Higham & Shelton, 2011), as stated previously.

The area on Paku Trail where the Proboscis Monkey has been observed is a foraging spot for the monkey due partly to the availability of food resources (see Chapters 4, 5 and 6). Their foraging path from the heath forest (medium closed heath forest) to the mangrove forest (coastal mangrove) also weaves through this area (Chapter 5), (Bennett & Sebastian, 1988; Salter et al., 1985; Yeager, 1989a) such that they may respond frequently to human disturbance. In addition, Proboscis Monkey was more sensitive to human disturbance on Paku Trail, although it was habituated to human presence at the boardwalk of Teluk Assam. This explains the highest score of feeding-response behaviour in this study. Despite the seasonal pattern of visitors accessing Paku Trail, disturbance from visitors continues to occur. Unless the impact of disturbance is incorporated into the day-to-day management of the park, there is a high likelihood that it will cause long-term changes in foraging behaviour and possibly displacement of animals to less suitable habitat.

7.5 CONCLUSIONS

Trail users' activities on-trail affected Proboscis Monkey's foraging behaviour. The types of trail users' activities on-trail triggered different responses in Proboscis Monkey. Among the trail users' activities on-trail, laughing and off-trail inflicted an adverse and disturbing effect on Proboscis Monkey's foraging behaviour. The impact of these activities had been more disturbing in relation to the number of trail users with the types of activities they performed on-trail. However, silent and standstill and binocular activities did not affect Proboscis Monkey's foraging behaviour. Proboscis Monkey had not responded to silent and/or standstill and binocular activities on-trail but they responded to all other activities. Among the Proboscis Monkey's foraging activities, feeding activity was the most affected by trail users' activities on-trail. This was partly due to most trail users walking on Paku Trail during the monkeys' feeding times, in addition to the types of activities trail users engaged in.

From these findings the following conclusions and recommendations have been made. Since Proboscis Monkey's feeding activities are very important for their survival in a small and isolated protected area such as Bako National Park, trail users' activities on-trail need to be regulated to minimize the impact on Proboscis Monkey's foraging behaviour. There are a number of possible sustainable approaches to managing trail user impacts on Proboscis Monkey's foraging behaviour. Among them are recommendations as stated below, which are based solely on the study reported in this chapter, i.e. visitor activities on trail, and their impact on Proboscis Monkey's foraging behaviour.

1. Park management should determine an appropriate standard level of use for Paku Trail.
2. Access to Paku Trail should be limited to a certain number of trail users during peak season, and to certain times of the day.

3. During feeding times, trail users on Paku Trail should be accompanied by park guides or tourist guides.
4. Interpretive signs should be placed at the trail entrance to remind trail users of activities that impact on Proboscis Monkey's foraging behaviour.
5. Activities that may have a potential impact on Proboscis Monkey should be regulated.
6. Interpretive talks should be conducted at the information centre to enhance visitors' knowledge and understanding of feeding ecology and foraging behaviour of Proboscis Monkey.
7. Finally, ecological research on the impact of trail users-Proboscis Monkey interaction and Proboscis Monkey response to activities on-trail should be intensified.

CHAPTER 8 GENERAL DISCUSSION, KEY CONSERVATION AND MANAGEMENT CONSIDERATIONS

8.1 ENVIRONMENTAL VARIATIONS

8.1.1 Habitat preference

Proboscis Monkey's preferred habitat as revealed in this study is referred to as a specific habitat characteristic. Each specific habitat characteristic is connected with ecological attributes of the natural environment that supports livelihood of the monkeys. The medium closed heath forest in Bako National Park offers suitable habitat because it provides good habitat requirements in terms of forest structure, trees which provide sleeping sites, connectivity, food plants and less intrinsic disturbance. The absence of large canopy gaps provides easy arboreal access for the monkeys. Canopy layers are connected and forest strata are evident with some dominant stands (Table 8.1) between 20 m and 30 m high. Most of these emergent trees are species from the family of Dipterocarpaceae.

Table 8.1: Habitat attributes of Proboscis Monkey in heath and swamp forests

Habitat attributes		Medium closed heath forests	Low closed heath forests	Flooded forests	Peat moss forests
Forest structure	D.B.H. class varies	Yes	No	Yes	Yes
	Some smaller trees and a few larger D.B.H.	Yes	No	No	Yes
	Some smaller trees and a number of larger D.B.H.	No	No	Yes	No
	Emergent trees ≥ 20 m	Yes	No	No	No
	Majority smaller trees D.B.H. class ≥ 10-14 cm but no D.B.H. class > 20-24 cm	No	Yes	No	No
Food plants	Some different species	Yes	No	No	No
	A few or a number of different species	No	Yes	Yes	Yes
	Three or more species density 100-300 trees per ha	Yes	No	No	No
	One or two species density 100-300 trees per ha	No	No	Yes	Yes
	One species density 100-300 trees per ha	No	Yes	No	No
Connectivity	Minimal gap size (≤2 m wide)	Yes	Yes	No	No
	A number of larger canopy gaps (≥2 m wide)	No	No	Yes	No
	Some larger canopy gaps (≥2 m wide)	No	No	No	Yes
	A number of crowns damaged	Yes	Yes	Yes	Yes
	Dense canopy	No	No	No	No
Disturbance	Selective removal of trees	No	No	Yes	Yes
	Fragmented			No	Yes
	Hunting	No	No	No	Yes
	Burning of plants	No	Yes	No	Yes
	Presence of tourists	Yes	No	No	No

A number of open spaces created by natural disasters are almost covered by the undergrowth through the processes of recruitment and succession. Having said this, canopy connectivity is well established which results in minimal vertical locomotion of the monkeys. Vertical locomotion most frequently happens at the interface between the medium closed heath forest and the mangrove forest at Teluk Assam due to a decrease in connectivity. Habitat 1 in the medium closed heath forest was the most preferred habitat of Proboscis Monkey where it was mostly found foraging. The reason is that this habitat class is composed of trees with dominant canopy connectivity, food plants and trees which provide sleeping sites. Naturally blended habitat suitability as demonstrated by the medium closed heath forest is not found in the low closed heath forest, the flooded forest and peat moss forest.

The low closed heath forest is not only composed of smaller trees, but also has low density of food plants compared to the medium closed heath forest, the flooded forest and the swamp forest, and therefore may not able to sustain a viable population of the monkeys if isolated. Besides the absence of larger trees, separation of the location from the mainland Bako National Park by the sea may also influence the long-term persistence of the monkeys (Turner, et al., 2003).

Flooded forest in Kuching Wetland National Park is dominated by some smaller trees. The absence of emergent trees is likely to influence the choice for sleeping sites, although it has a number of larger trees and food plants. The presence of larger canopy gaps may expose the monkeys to any potential threats when they need to venture down on the forest floor. This in turn influences the long-term persistence of the monkeys if not connected with the riverine mangrove habitat which occupies almost the entire park.

As demonstrated by this study, swamp forest in Maludam National Park has some larger canopy gaps and is also fragmented. Ecologically, swamp forest in this natural setting is located further inland, isolated and disconnected from coastal and riverine mangroves which are also under ongoing threats (see Chapter 4), especillay human disturbance. The ongoing disturbances outside the park boundary may have caused edge effects however the main concern is considerable ongoing disturbance inside the park. As a result this habitat may not be suitable to sustain the population of these monkeys.

The quality of mangrove habitat is ecologically different from the heath and swamp forests. In Kuching Wetland National Park, riverine mangrove has a number of different species of food plants and good forest structure (Table 8.2). The existing variety of mangrove species has been able to provide a good sanctuary for the monkeys.

Table 8.2: Habitat attributes of Proboscis Monkey in the mangrove forests

Habitat use indicators		Coastal Mangrove			Riverine Mangrove		
		BNP		Selabat	KWNP	Selabat	Bako High School
		Teluk Assam	Teluk Delima				
Forest structure	D.B.H. class varies	No	Yes	Yes	Yes	No	No
	Majority smaller trees and a number of larger D.B.H.	No	Yes	No	No	No	No
	Some smaller trees and a few of larger D.B.H.	No	No	Yes	No	No	No
	Some smaller trees and a number of larger D.B.H.	No	No	No	Yes	No	No
	Some smaller trees and no D.B.H. class more than 25-29 cm	No	No	No	No	Yes	No
	Emergent trees ≥ 20 m	Yes	Yes	Yes	Yes	No	No
	Majority smaller trees D.B.H. class ≥ 10-14 cm but no D.B.H. class > 20-24 cm	Yes	No	No	No	No	No
	Majority smaller trees D.B.H. class ≥ 10-14 cm but no D.B.H. class > 15-19 cm	No	No	No	No	No	Yes
Food plant	Majority single species stands	No	No	No	No	Yes	No
	Single species stands	No	No	Yes	No	No	Yes
	A number of plant species	Yes	Yes	No	Yes	No	No
	One or two species density 100-300 trees per ha	No	No	Yes	Yes	Yes	No
	One species density > 500 trees per ha	No	No	No	Yes	No	Yes
	One species density 300-500 trees per ha	No	Yes	No	No	No	No
	Species density < 100 trees per ha	Yes	No	No	No	No	No
Connectivity	Minimal gap size (≤2 m wide)	No	Yes	No	Yes	No	Yes
	A number of larger canopy gaps (≥2 m wide)	Yes	No	Yes	No	Yes	No
	Some larger canopy gaps (≥2 m wide)	No	No	No	No	No	No
	A number of crowns damaged	Yes	No	Yes	Yes	Yes	Yes
	Dense canopy	No	Yes	No	No	No	No
Disturbance	Selective removal of trees	No	No	Yes	Yes	Yes	No
	Fragmented	No	No	No	No	No	Yes
	Isolated & surrounded by land clearing	No	No	No	No	No	Yes
	Species died due to environmental factors	Yes	No	No	No	No	No
	Hunting	No	No	No	No	No	No
	Burning of plants	No	No	No	No	No	No
	Presence of tourists	Yes	Yes	No	No	No	No

This type of mangrove provides good sleeping sites and proper arboreal connectivity. The absence of predation is partly due to the presence of humans residing near the park and engaging in subsistence fishing. With the exception of riverine mangrove in Kuching Wetland National Park and coastal mangrove at Teluk Delima, mangrove habitat in other sites is less suitable for the monkeys due to disturbance that deteriorates their quality. Teluk Delima is a small mangrove pocket existing between two capes, which is naturally restricted from expanding. It may not be able to sustain the population of Proboscis Monkey if so isolated, although it has good forest structure and preferred food plants for the monkeys. While some mangrove trees are dying at Teluk Assam, mangrove habitats at Bako High School and Selabat are both isolated and face ongoing human disturbance.

8.1.2 Food availability

The availability of food resources is a key indicator of quality habitat for Proboscis Monkey. All the study sites have food resources for the monkeys which are available in both dry and wet seasons. The monkeys ate plant parts from 53 species of plant in the medium closed heath forest and the coastal mangrove in Bako National Park, and six species in the riverine mangrove in Kuching Wetland National Park. These plant parts were young leaves, shoots, flower buds, fowers, green fruits, seeds and leaf bases. Of these plant parts young leaves and shoots were most frequently eaten by the monkeys. The monkeys' most preferred food plants were *Syzygium* spp., *Garcinia* sp. and *Sonneratia alba.* The density of *Syzygium* spp. And *Garcinia* spp. in the medium closed heath forest and *Sonneratia alba* in the riverine mangrove in Kuching Wetland National Park were higher compared to other study sites. In the medium closed heath forest most of these food plants are available in Habitat 1. The frequency of behavioural activities was also higher in this habitat compared to other habitat classes. As most food resources, especially young leaves and shoots, are available in the upper canopy (Harris et al., 2010; Hladik, 1978b; Isbell, 1991; Lowman & Moffett, 1993), behavioural activities were higher in the 1st and 2nd stratra of forest stands in this study. In Kuching Wetland National Park, behavioural activities were higher in the top and middle levels of tree crowns, partly due to the availability of young leaves and shoots.

Some food plants were foliating and fruiting over the study period in the medium closed heath forest. A previous study indicated that some trees in tropical forests were regularly flowering and fruiting ouside the general flowering and fruiting events (Appanah, 1985). As a result of this, food availability is not a major problem in Bako National Park except in the coastal mangrove or Habitat 3 where *Sonneratia alba* are dying. As this species is the most preferred mangrove food plant, the park management should conduct intensive research to identify the actual cause of the problem. Subsequently remedial action should then be taken to restore this habitat which is a popular spot for viewing the monkeys. In Kuching

Wetland National Park the availability of *Sonneratia alba* and other food plants suggest a higher frequency of behavioural activities in the central polygon where the monkeys were mostly sighted. Mangrove forest is a major food supplier for Proboscis Monkey in this habitat where higher density of *Sonneratia alba* is growing on the river bank and near coastal areas. In fact, Proboscis Monkey have many choices of food resources as evidenced by their varied dietary habit in this study.

Besides the availability of food resources, Proboscis Monkey show clear preference in diet - consuming more young leaves than fruits, seeds, flower buds, flowers and leaf bases. There is no clear indication that the monkeys would switch from young leaves to other parts of plants because over the study period young leaves were never absent from their everyday diet. Availability of food resources and the degree of diet in Proboscis Monkey are important factors affecting the sustainability of the population in Bako National Park and Kuching Wetland National Park.

In swamp forests, there were a few food plants with lower densities compared to those available in the medium closed heath forest. These food plants were mostly found further inland than on the river bank. The lower population density of Proboscis Monkey at swamp forest in Maludam National Park compared to Bako National Park and Wetland National Park may be due to a lower density of food resources in this habitat (Bennett, 1992; Hon & Gumal, 2004; Sabki & Tisen, 1998). While the population of monkeys in Kuching Wetland National Park is between 60 and 80 animals (FDS, 2010a), their population at Teluk Assam in Bako National Park is increasing from 106-144 in 1981 (Salter & MacKenzie, 1981) to 275 in 2004 (Zaini, et al., 2004). Food availability and diet flexibility are the key ecological and biological indictors for long-term conservation of these animals and should be considered in the day-to-day management and future management plans of these three parks. Incorporating this into management strategies should be based on up-to-date research findings because food availability and diet flexibility may change over time.

8.1.3 Seasonal variation

Seasonal variation between the wet and the dry seasons had influenced feeding activities of Proboscis Monkey. Feeding during the wet season was higher in both Bako National Park and Kuching Wetland National Park as opposed to the dry season. The changes in food availability between wet and dry seasons may explain the difference in feeding between these two seasons. Resting and travelling in both study sites were significantly different between the wet and the dry seasons, whereas 'other' activities were not significantly different. Resting was higher during the wet season in both study sites whereas travelling was higher during the dry season in both study sites. However, these two activities were lower compared to feeding in both seasons. As the food plants are clumped in both study sites the monkeys did not need to engage more in travelling. Most of their foraging activities were concentrated in Habitat 1 (medium closed heath forest) in Bako National Park and in the Central Polygon (riverine mangrove) in Kuching Wetland National Park. Most of the activities they engaged in were feeding and resting in these habitat classes (Habitat 1 and Central Polygon) which explains the lower frequency of travelling compared to feeding and resting.

Proboscis Monkey mostly preferred to take young leaves during the wet season as opposed to dry season in Bako National Park and Kuching Wetland National Park. Feeding on young leaves was significantly different between the wet and the dry seasons in both study sites. Young leaves (especially mangrove species) are the main source of food and are preferred over other parts of food plants. Foliation of mangrove trees was abundant during the wet season in both national parks as opposed to the dry season and this variation was significantly different. This suggests the higher feeding activities during the wet season.

Both coastal and riverine mangroves are important habitats for Proboscis Monkey where food resources are available during both wet and dry seasons. The foliation of mangrove species in Bako National Park was significantly correlated with feeding. Moreover, there was a significant correlation between the frequency of feeding and the intake of young leaves in Bako National Park and between the frequency of feeding and the intake of green fruits in Kuching Wetland National

Park. Therefore seasonal variation in the availability of food resources in mangrove habitat influenced the frequency of feeding and diet of Proboscis Monkey.

Given this finding, seasonal variation in food availability, feeding activities and diet is a significantly phenomenon that park management should consider in their management strategies. Because foraging activities were lower during the dry season when lower availability of food resources, this suggests that Proboscis Monkey may be more vulnerable to human disturbance during the dry season, when the availability of food resources is limited and hence at a time when they can least afford it.

8.2 DISTURBANCE FACTORS

8.2.1 Human factors

In Bako National Park, visitors' activities on Paku Trail that affected the foraging behaviour of the monkeys were walking, talking, photographing, pointing, laughing, and off-trail movement. Visitors who kept silent and used binocular to view Proboscis Monkey did not affect the foraging behaviour of the monkeys. The activities that seriously affected foraging behaviour of the monkeys were off-trail movement and laughing which caused 100 per cent of the observed feeding-response behaviour. The park management should employ some possible approaches to minimize the impact of these activities on the monkeys, including trail regulation and education. The impact of these activities not only caused displacement of the monkeys from the trail (de la Torre et al., 2000) but also spoiled visitors' experience. Paku and Lintang Trails are among the trails that have always been accessed by visitors to observe Proboscis Monkey. Proboscis Monkey has always been scared away and difficult to sight, dependent on the number of visitors and the types of activities on the trails. These trails provide easy access to sight Proboscis Monkey for day-only-visitors (DO). DO mostly preferred Paku Trail to sight the monkeys (Budeng, 2004) due perhaps to this trail being more challenging and thrilling compared to easily sighted Proboscis Monkey in park headquarters.

In the low closed heath forest, the destruction of the natural setting due to fire that destroyed some of food plant species, suggests that human disturbance is a serious threat to this ecosystem. Human disturbance is likely to continue in this habitat due to a lack of supervision or monitoring and limited law enforcement. Therefore a preventative measure should be incorporated into the day-to-day management of the park to protect and conserve this forest habitat.

The presence of tourist boats that came closer to observe the monkeys foraging in mangrove trees was more disturbing to the monkeys in Kuching Wetland National Park. The monkeys ran away from the riverine mangrove and moved further inland when being approached by tourist boats. The foraging activities of the monkeys were totally disturbed by the presence of tourist boats that manoeuvred between

Sg. Jebong and Sg. Pergam. Management guidelines should have been established and enforced to regulate tourist boats although this park is not opened yet to the public. The guidelines include among others:

1. In any circumstances tourist boat should be in the position at least 15 m away from the monkeys foraging in the trees,

2. Precautionary measures must be taken to minimize noise when viewing the monkeys,

3. A tourist boat should not be stationed more than 10 minutes in the vicinity of the monkeys under observation, and

4. Daily observation time should always be changed and regular visits during active feeding time must be avoided.

The presence of local people in Kuching Wetland National Park that undertake routine work and use the river daily as a mean of transportation has also disturbed the monkeys. Human disturbance in terms of selective removal of trees has degraded the quality of monkeys' habitat in the flooded forest in Kuching Wetland National Park. This is an important aspect of conservation that the park management should consider because the selective removal of trees, although irregular, would decrease the forest stock, especially food plants. Thus the colonization of new species of plants as a result of this activity would change the forest structure (Arroyo-Rodríguez & Dias, 2010) and the slower succession process to establish connectivity would adversely affect arboreal movement in the canopy.

Human disturbance in terms of selective removal of trees has also degraded the quality of monkeys' habitat in the peat moss forest at both study sites within Maludam National Park. Besides the removal of trees, a series of cut lines due to encroachment by heavy machinery has created larger forest gaps. This in turn reduces connectivity which would affect the movement of the monkeys. The fragmented habitat adjacent to the park would also hinder the monkeys' movement to access their food plants. Other human disturbances include burning of plant species along the river, and hunting for wild animals which is also a major threat to the monkeys. The park management should consider a strict law of enforcement within the park and joint management with the relevant authorities in land use planning outside the park. Ecologically, peat moss forest in this natural setting is located further inland, isolated and disconnected from coastal and riverine mangroves which are also under ongoing threats. The ongoing disturbances outside the park boundary may have caused edge effects however the main concern is the ongoing considerable disturbance inside the park.

Other study sites have different types of threats derived from unregulated human activities. These threats include, amongst others, land clearing for infrastructure and aquaculture. Land clearing was the main factor that has caused the mangrove ecosystem in Bako High School to become fragmented and isolated.

8.2.1.1 Habituation

As demonstrated in this study, changes in Proboscis Monkey behaviour have been detected especially in Bako National Park. For example, the monkeys (especially the juveniles) were easy to observe at 3 m away from the researcher as the study progressed. They are also already habituated to the noise of tourist boats at the Teluk Assam boat terminal, unlike Howler Monkeys (*Alouatta seniculus*) in Brownsberg Natuur Park, Suriname, that demonstrate less response to, or avoidance of disturbing noises (Westin, 2007). Regular visitation has caused habituation within the monkeys at Teluk Assam. The monkeys mostly came to the coastal mangrove at Teluk Assam in the morning, and sometimes remained there till afternoon, despite some visitors present on the boardwalk observing them. On a number of occasions the monkeys stayed foraging in the heath forest on Paku Trail although there were visitors present on the trail observing their behaviour. At Teluk Delima the monkeys are very shy and always move away from the presence of visitors.

Habituation is not only caused by visitors who wish to view the monkeys, but also by researchers who come regularly to the same place to conduct research on the monkeys. Many previous studies demonstrated that regular visitation by visitors

(Griffiths & van Schaik, 1993; Reynolds & Braithwaite, 2001) and researchers (Cipolletta, 2003; Paulus, 2009) have caused habituation in primates and other wildlife. Conversely, in Taı¨ National Park, Coˆte d'Ivoire, the presence of researchers and visitors is generally assumed to provide a protective effect from hunting and poaching, and thus a refugia for Colobus Monkey (*Procolobus badius*) (Campbell et al., 2011). In this study, Proboscis Monkey in Kuching Wetland National Park were very hard to observe in the first three months. As the study progressed, the monkeys were slightly more at ease with the researchers and thus became easier to observe over the remainder of the study period. This incidental observation confirmed that Proboscis Monkey behaviours are changed and habituated by regular research visits.

Although habituation is a temporary phenomenon in relation to Proboscis Monkey behaviour, it would change foraging behaviour of the monkeys. Close contact with the monkeys would not only change their feeding patterns but also create the potential to transmit disease (Almeida Cunha, 2010; Bouros, 2012) which could cause severe and permanent effects to the animals. The issue of habituation and close contact between the Proboscis Monkey population and visitors therefore requires special consideration by the park management in day-to-day operation of the park. Lack of consideration regarding habituation would not only adversely affect the monkeys' behaviour and populations but also spoil viewing experiences among visitors who wanted to observe the monkeys in a more natural way.

Habituated Proboscis Monkey in the park headquarters have always been sighted during feeding time in the morning, afternoon and even in the evening.

8.2.2 Development

Improper planning and unsustainable management of development would jeopardise the intact habitat of Proboscis Monkey in the protected areas. Bako National Park is the most distant from mainstream development but Kuching Wetland National Park is almost surrounded by development, as is Maludam National Park which is surrounded by infrastructure and settlement development. Park facilities within Bako National Park are still within acceptable limits and further infrastructure development within the park is not really necessary. The development surrounding and within Kuching Wetland National Park, which includes human settlements and fishing villages, may have changed the ecology of the mangrove ecosystem (Nyanti et al., 2012). For example, the quality of water in the river system including Sg. Salak is very low (Rosli et al., 2012).

Non-physical development in terms of tourism promotion has identified Kuching Wetland National Park as an alternate tourism destination to observe both terrestrial and marine wildlife. As demonstrated in this study the unregulated tourism activities within this park have affected the monkeys' behaviour. The impact of tourism development was not evident in Maludam National Park because it is rarely visited. However the development of infrastructure within the park has facilitated illegal access such that human disturbance was evident in terms of timber extraction and collection of other forest produce.

Minor development is good for wildlife tourism in the parks if the objective of the development is to provide proper facilities for wildlife viewing, however it should be done according to good management practice. Construction of boardwalks in sensitive areas to avoid erosion, construction of interpretative and directive signs, and the provision of platforms and blinds for wildlife viewing could enhance wildlife tourism and the visitor experience. For Bako National Park, especially Paku Trail, interpretative signs are urgently needed to communicate "do's" and "dont's" among the visitors in relation to sighting Proboscis Monkey and other wildlife. These interpretative signs are also an urgent requirement for Kuching Wetland National Park and Maludam National Park. The park management should consider the development of sustainable tourism strategies in the management plans of the parks to minimize the impact of development on the wildlife, especially Proboscis Monkey.

Development is always incompatible with natural ecosystems unless precautionary measuresare taken right from the beginning of any development project. Environmental aspects of sustainable development should not be taken lightly, so as to avoid compromising the use of resources for future generations. If this concept is well understood by all stakeholders there will be no unnecessary conflict between development and the protection of natural habitat for wildlife. It is therefore extremely important that the habitat of Proboscis Monkey be protected for the long-term persistence of the monkeys, and to sustainably perpetuate an economic value chain in relation to tourism development.

8.2.3 Competition for food plants

Sonneratia alba grows at the forefront of coastal areas and rivers systems, which are currently subject to various threats that can diminish this species. *Sonneratia alba* at Teluk Assam in Bako National Park is mostly dying and this may be due to dieback. The death of mangrove species may also be partly due to sedimentation (Ellis et al., 2004; Ellison, 1999). This mangrove ecosystem has totally changed as evidenced by the sandy floor that covers most of its phenuematophores. At Teluk Delima a number of mangrove species were also observed to be dying, which may be due to similar phenomenon as that occurring at Teluk Assam. The absence or reduction of food plants may bring unfavourable effects to the monkeys. In Kuching Wetland National Park, some of *Sonneratia alba* have defoliated, however over-grazing by the monkeys themselves has been the cause of this (FDS, 2010a).

Most food plants preferred by Proboscis Monkey are also beneficial to humans, especially certain fruits of *Syzygium* spp. which are edible. Timber from *Shorea* spp., *Syzygium* spp. and *Garcinia* spp. are sometimes used for making houses, boats, furniture and other domestic purposes in the fishing villages near Maludam

National Park and Kuching Wetland National Park. These activities may occur due to lower socio-economic status in these villages, and also as a result of high local demand for the timber, especially from *Shorea* spp. As food plants are the key indicator for determining the quality of habitat, protection of these food plants is a great commitment and should be incorporated into park management strategies.

8.2.4 Fragmentation beyond the boundary

There was no evidence of habitat loss in the study sites except within Maludam National Park. In Maludam National Park, subdivision of landscape cover outside and inside the park may have caused deterioration in the quality of habitat within the park through the diminishment of wildlife corridors. Subdivision of landscape cover beyond the boundary due to infrastructure and agriculture development (such as oil palm plantations) creates some larger canopy gaps and a number of isolated habitat patches. Proboscis Monkey have never been seen foraging in open space (Bennett, 1986b) suggesting that these animals could not survive in small forested fragments. The fragmentation beyond the park boundary not only reduces the arboreal connectivity but also availability of food resources. The future of the existing mangrove ecosystem beyond the park boundary of this study site is not guaranteed unless sustainable land-use planning is incorporated into state land development policy.

In Bako National Park the existing forested buffer area beyond the boundary is too small to sustain the long-term persistence of the monkeys if isolated. Fragmentation outside that park boundary has also reduced connectivity which in turn affects the monkeys' movement to search for food. Intensive infrastructure and human development beyond the boundary in the south-western part of Kuching Wetland National Park may have caused deterioration of the riverine mangrove ecosystem, as this part of the park is connected with the mainland where municipal waste disposal in river systems is occurring.

Although the national parks in this study have been compromised through various human activities, gazetting more totally protected areas is a serious commitment by the Malaysian State Government of Sarawak to conserve the monkeys. This policy is being implemented in areas such as the mangrove habitat in Lawas Division, which has been earmarked for a new gazetted totally protected area to conserve this habitat of Proboscis Monkey.

8.3 CONSERVATION AREA CONSIDERATIONS

8.3.1 Habitat quality

In this study the quality of habitat for Proboscis Monkey relates to the ability of habitat to support the livelihood of the monkeys in disturbed and/or fragmented landscapes. Most of the monkeys' habitats assessed as part of this study have been disturbed, and some are fragmented and isolated. In addition, landscape outside the protected areas is mostly fragmented. Habitat size that can support ecological carrying capacity is able to protect monkeys from extinction in case of shortages of food resources and other ecological and biological needs. Therefore, establishment of protected areas which is not based on key habitat characteristics of population density, home range size and food resources of the monkeys may not guarantee their long-term survival, if the habitat is fragmented and isolated.

Proboscis Monkey in this study mostly preferred mangrove habitat however this habitat has been altered by a variety of threats as discussed earlier in this chapter. Therefore, the conservation of this primate and its habitat should be incorporated into the management planning of protected areas and coastal land development in particular. Not only the need for environmental aspects of any developments to be considered, but also the quality of forest attributes that provides a much better foraging habitat for the monkeys should be protected. Because primate abundance is related to vegetative cover of habitat (Rovero & Struhsaker, 2007), a huge conservation area would not guarantee the quality of habitat if habitat attributes (for example canopy gaps, connectivity, food plants) are not suitable for foraging. Fragmentation within the habitat would inflict a long-term effect on the monkeys because naturally mangrove forest has less connectivity. Therefore, habitat quality is an important aspect to be considered in land-use planning to design and establish new protected areas for this primate.

8.3.2 Conservation area boundary and transition area

Maintaining and establishing transition areas is equally important when gazetting any new protected areas, because transition areas provide better protection to both habitat and species to be protected. Strict enforcement with park staff patrolling near the transition zone would be able to curb any encroachment that causes deterioration in the integrity of the protected area boundary. Besides the enhancement of protected areas, transition areas can serve other purposes dependent upon the quality of the area. In pristine environments, transition areas can also serve as foraging areas if characterized by necessary habitat requirements for the protected animals.

In the Malaysian State of Sarawak, the existing laws (i.e. National Parks and Nature Reserves Ordinance 1998, and Wild Life Protection Ordinance 1998) do provide protection for this primate and its habitats. But due to a lack of enforcement of these laws, the monkeys' habitats have faced continuous threats from anthropogenic activities. It is therefore recommended that, in the absence of any other relevant legislation, a clause or regulation specifically relating to the protection of transition areas should be enacted in any amendment made to these two ordinances. Nonetheless, this measure is not only to protect the integrity of both protected areas and transition areas, but also the biodiversity of the entire ecosystem which includes the protected animals themselves (Bubb, Fish, & Kapos, 2009). This can be achieved with a strong political will, alongside interdisciplinary commitments among the relevant agencies or stakeholders.

8.3.3 Human management

Human management is a prime park activity in the study sites (Bako National Park, Kuching Wetland National Park and Maludam National Pak) besides park maintenance and conservation. In Bako National Park, park activity has emphasized customer service management as a main agenda in achieving visitor satisfaction. Visitor satisfaction is always related to services that the park offers, besides infrastructure and accommodation, and other park activities. Although the park is a public park which is managed by the Malaysian State Government of Sarawak, overuse has been a significant management problem, as evidenced by the increasing impact of use on trails or eroded trails. Use of park resources beyond their capacity would otherwise diminish visitor satisfaction. More significantly, overcrowding on trails (especially Paku Trail in July and August, particularly over the weekend and in schools holidays) may have produced a “tragedy of the commons” (Hardin, 1968) that leads to resource damage and spoils the visitors’ experience. While other trails have shown resources damage, the presence of humans has influenced the foraging behaviour of Proboscis Monkey in the park. The absence of Proboscis Monkey on a number of days in each month on Paku Trail as a result of overuse, is the key impact indicator for the park management to consider in a Management Plan to remedy these problems.

Management of visitor activities is needed for Bako National Park to sustain park resources. Proboscis Monkey has been the main attraction amongst the unique creatures in the park, however the exceeded trail capacity, high numbers of visitors and intense on-trail activities have disrupted Proboscis Monkey's foraging behaviour. It is therefore recommended that a visitor carrying capacity for the park (Almeida Cunha, 2010; Duffus & Dearden, 1990) should be imposed, in particular during peak seasons, to minimize the visitor impact on the monkeys and improve visitors' quality of experience. This can be done by managing the visitors accessing the trails with regulated park activities. This also includes considering time management based on the time of day when Proboscis Monkey is least susceptible to disturbance from an activity that is critical to their survival. As demonstrated by all age and gender categories in this study, the critical activity was feeding which accounted for the highest per cent frequency of daily behavioural events. Feeding was also the behaviour which most frequently affected by visitors' activities on-trail, and which also showed the highest response behaviour in the monkeys. Therefore, the park management should incorporate an active feeding time in the morning, afternoon and the evening into the day-to-day management of the park, to regulate visitors accessing the trails and limit the level of disturbance experienced by the monkeys whilst foraging in the trees.

Human management is a very critical aspect of management for both Kuching Wetland National Park and Maludam National Park. Both of these parks have been lacking in management and supervision of human activities. The existing ranger station in Maludam National Park which is manned by a park ranger or park manager has served some good purposes. This should have included, among other responsibilities, the monitoring of human activities within the park that may affect the quality of habitat. As external agriculture is expanding rapidly, the capacity of park staff to effectively manage human activities is of great importance to safeguard the park. The main concern of the park management should be to restore the quality of habitat for the long-term conservation of the monkeys, which would in turn enhance the tourism value of the park. Moreover, park management should establish a joint-management committee with the local people living near Maludam and Kuching Wetland National Park, in addition to the Special Park Committees. This joint committee would serve to advocate effectively for the importance of conserving the monkeys and their habitats. The affected local people should be provided with information and resources to enhance community understanding of the economic value of conserving this primate and the related benefits to ecotourism, which would in turn contribute to minimizing the impact of human disturbance.

8.3.3.1 Visitor management

Visitor impact management (VIM) is a common approach that is widely used to identify and evaluate the issues, impacts and problems associated with visitation, and recommend alternate management strategies (Ceballos-Lascurain, 1996). Although the impact of visitor behaviour could be manageable, lack of management strategies in the day-to-day operation of Bako National Park has adversely affected foraging behaviour of Proboscis Monkey. VIM should be considered as an important technique in management planning to sustain the park resources and promote sustainable wildlife tourism. While the number of visitors accessing the park is increasing every year, repeat visitors and their levels of satisfaction (Moore & Polley, 2007) need to be maintained through strategies such as VIM techniques to increase park revenue for use in conservation activities both within the park, and on Proboscis Monkey in particular.

VIM should also be incorporated into the management plans of Maludam National Park and Kuching Wetland National Park in tandem with tourism development within and surrounding the parks. Although the parks (especially Maludam National Park) are rarely visited by tourists, the implementation of VIM should be taken into consideration for effectively managing any potential or actual impacts of visitation which may become apparent.

8.3.4 Infrastructure

The development of infrastructure in protected areas is provided to enhance visitor enjoyment and appreciation of the environment, whilst in a wider context it is targeted to minimize visitors' impacts on biodiversity (Wimpey & Marion, 2011). There are two approaches which can minimize the impact of infrastructure development as follows.

a. Wildlife-friendly structures

The purpose of wildlife-friendly structures is to minimize the biological impact of infrastructure development (Budeng, 2004). This can be implemented through detailed guidelines for the development of tourist and park facilities (McNeely, Thorsell, & Ceballos-Lascuráin, 1992). As the development of these three national parks is under the purview the Malaysian State Government of Sarawak, the guidelines should be incorporated into the management plan of the three national parks in particular, and also in the state's land development policy. Similar guidelines exist within the current Malaysia Ecotourism Master Plan, however they do not give legislative power to the State Government of Sarawak.

b. Control structure for human behaviour

Park control structures should be designed to control visitor traffic and behaviour whilst allowing for exploration of the beauty of the environment in protected areas (Catibog-Sinha, 2008; Worboys et al., 2005). These control structures for human behaviour are the add-ons to park guides and interpretative talks that help promote better understanding of conservation goals (Pereira & Mykletun, 2012). Directive signs and educational or interpretative infrastructure along the trails and in sensitive areas are still lacking in Bako National Park, Maludam National Park and Kuching Wetland National Park. These structures serve to assist visitors exploring the parks, as well as regulating visitor traffic and informing them of sensitive areas. These structures are not only designed to facilitate and guide the movement of visitors along the trails and in sensitive areas, but also to provide unique experiences for those who wish to sight wildlife (Bowen & Santos, 2006).

Providing loop walks or trails is one of the control structures that can minimize visitor impacts and provide quality of experience, by maintaining interest for visitors who may otherwise lose interest if returning via the same trail. Trails are a core component of park infrastructure that influence travel patterns and the visitor experience (Wimpey & Marion, 2011). In addition, observation platforms, resting shelters and/or blinds for observing wildlife can also be provided along loop trails. While there are observation platforms or resting shelters in Maludam National Park, other structures such as directive and interpretative signs in particular have not been built yet. Directive and interpretative signs are an urgent need in Kuching Wetland National Park as a means of informing tourists of activities that disturb the monkeys.

Park management should consider including control structures for human visitation in a Management Plan for the three national parks, that ensures the construction of such structures as an urgent need, expecially in heavily visited areas or trails within the parks. This measure should also be taken to minimize the impact of intensive use on natural features and wildlife in the most visited areas (Budeng, 2004). Besides promoting quality of experience, user-friendly facilities are a very important aspect of park infrastructure that can minimize visitor impact on biodiversity and increase levels of visitor satisfaction (Catibog-Sinha, 2008; Wimpey & Marion, 2011).

8.4 CONSERVATION AND MANAGEMENT IMPLICATIONS

8.4.1 Habitat rehabilitation and replanting

A rehabilitation programme involving the replanting of mangrove trees has been carried out by Sarawak Forest Department in previous years. This programme was implemented outside the protected areas throughout Sarawak. Besides protecting seashores and river banks from ongoing erosion, replanting mangrove species contributes to carbon sinks. Replanting *Sonneratia alba* is of importance to Proboscis Monkey since this mangrove species is mostly preferred by the monkeys, and is found within coastal and riverine mangrove ecosystems in Sarawak. Since Proboscis Monkey also feeds on other mangrove species such as *Avicennia* sp. replanting of other mangrove species would enrich food resources for the monkeys. In Kuching Wetland National Park, the south-western part of the park in particular would benefit from the establishment of a mangrove corridor to connect the park with mangrove habitat outside the park. Such a rehabilitation project could be established through a community participation programme designed to promote mutual understanding between park management and the local community. This programme could include, among other aspects, an awareness programme on the importance of mangrove species to sustaining marine ecosystems as a breeding ground for aquatic life and fisheries. Therefore, mangrove rehabilitation programmes cannot only restore quality habitat for Proboscis Monkey, but importantly also assist in enhancing subsistence fishing practices of the local fishing communities.

8.5 FUTURE RESEARCH

As Proboscis Monkey is an endangered species and protected within the Malaysian State of Sarawak by the Wild Life Protection Ordinance 1998 and National Parks and Nature Reserves Ordinance 1998, the long-term conservation of this primate and its habitat should be based on empirical data. In this respect, two categories of research as listed below could be conducted in Proboscis Monkey's habitats throughout Sarawak:

a. Research inside protected areas

b. Research outside protected areas

Research inside protected areas such as Bako National Park, Kuching Wetland National Park, Maludam National Park, Ulu Sebuyau National Park and Samunsam Wild Life Sanctuary should focus on population density of the monkeys and reproductive success. Ongoing processes of habitat modification should be monitored for appropriate action and/or rehabilitation. Economic aspects of Proboscis Monkey in both Bako National Park and Kuching Wetland National Park are also of importance due to the importance of these areas as popular destinations for sighting the monkeys. Outside protected areas where Proboscis Monkey is reported to occur, research on ecology, foraging behaviour and habitat suitability are of paramount importance. These should be included into land-use planning and the assistance of local communities sought in developing conservation plans for the species.

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GLOSSARY

In this thesis the following words are used according to the definitions outlined.

Dipterocarp Forests	Forests dominated by community of trees from family of Dipterocarpaceae. Deciduous dipterocarp forest varies considerably in stature and the openness of the canopy, but is dominated throughout its range by a characteristic group of tree species, including six deciduous (or semi-deciduous) dipterocarps (Corlett, 2009).
Forested	A terrestrial region of land densely covered by trees (Bennett, 2001). It is an area of >0.5 ha with >10 per cent tree canopy cover, with 'trees' defined as plants capable of growing at least 5m tall (FAO, 2010).
Heath Forest	A formation of tropical rain forest which is often less tall and with smaller leaves than forests of the much more widespread Tropical Lowland Evergreen Rain Forest Formation (Proctor, 1999). These forests grow on acidic, sandy podzolic soils of the Neotropics and Borneo where slowly decomposing organic matter accumulates at the soil surface. They are known locally as caatinga in Venezuela, campina or campinarana in Brazil, wallaba in the Guianas and kerangas in Borneo (Moyersoen, Becker, & Alexander, 2001).
Hill Mixed Dipterocarp Forests	Forests found in the interior, upriver areas, extending from coastal peat swamps up to heights of 1,500 m (FDS, 2012b).
Mixed Dipterocarp Forests (MDF)	Forests formed from family of Dipterocarpaceae and other families of forest stands (e.g. Anacardiaceae, Annonaceae, Euphorbiaceae, and Verbenaceae) (FDS, 2012b).
Montane Forests	Forests occur over 1, 500 m altitude (FDS, 2012b). In areas with strong rainfall seasonality , where the lowland vegetation is deciduous and regularly burns, the lower montane forest is largely evergreen and fire-intolerant (Corlett, 2009).
Peat Swamp Forests (PSF)	Forests located at low-lying coastal plains but immediately behind the coastline and with a high water table reaching inland along the lower reaches of the main river systems

	(FDS, 2012b). In peat swamp forests the layer of peat can be from 0.5m to >10m and because the water table is higher than the surrounding area, the only external input of water and nutrient is from rainfall (Corlett, 2009).
Permanent Forest Estate (PFE)	Forests established under the Forests Ordinance cap 126 that include three categories of forests namely Forest Reserves, Protected Forests, andCommunal Forests (FDS, 2012b).
Primary Forests	A "climax forest type" for a given region and environment, whichis relatively stable (Chokkalingam & De Jong, 2001). Primary forests are also defined as forests of native species, in which there are no clearly visible indications of human activity and ecological processes are not significantly disturbed (FAO, 2010).
Totally Protected Area (TPA)	Forest lands so designated under the provisions of the National Parks and Nature Reserves Ordinance, 1998 and Wild Life Protection Ordinance, 1998. These forest lands are managed to generate sustainable benefits for the society (FDS, 2012b).
Secondary Forests	Successional forests that develop after clearingof the original forest, and secondary succession is completewhen they develop again into climax communities or primary forests (Chokkalingam & De Jong, 2001).

Appendix 1

Protected Areas of Sarawak as of October 2012

No.	National Parks	Division	Land Area (Ha)	Water Bodies (Ha)	Total Area (Ha)	Date of Gazette	With effective from	Boundary (Km)
1.	Bako National Park	KUCHING	2,727.0	0.0	2,727.0	30.04.1957	30.04.1957	42.5
2.	Gunung Gading National Park	KUCHING	4,196.0	0.0	4,196.0	27.10.1988	27.10.1988	32.3
3.	Kubah National Park	KUCHING	2,230.0	0.0	2,230.0	11.05.1989	01.12.1988	29.2
4.	Tanjung Datu National Park	KUCHING	1,379.0	0.0	1,379.0	19.05.1994	16.03.1994	17.5
5.	Talang Satang National Park	KUCHING	0.0	19,414.0	19,414.0	04.11.1999	26.08.1999	35.4
6.	Kuching Wetland National Park	KUCHING	6,610.0	0.0	6,610.0	10.10.2002	24.07.2002	55.7
7.	Santubong National Park	KUCHING	1,410.0	0.0	1,410.0	19.07.2007	28.02.2007	20.0
8.	Bungo Range National Park	KUCHING	8,096.0	0.0	8,096.0	25.03.2010	25.02.2009	53.8
9.	Sedilu National Park	SAMARAHAN	5,970.0	0.0	5,970.0	08.09.2010	01.12.2010	49.6
10.	Batang Ai National Park	SRI AMAN	24,040.0	0.0	24,040.0	11.04.1991	01.01.1990	104.3
11.	Maludam National Park	BETONG	43,147.0	0.0	43,147.0	31.05.2000	17.02.2000	108.2
12.	Rajang Mangroves National Park	SIBU	9,373.0	0.0	9,373.0	03.08.2000	29.05.2000	51.7
13.	Pelagus National Park	KAPIT	2,041.0	0.0	2,041.0	02.07.2009	26.02.2009	26.5
14.	Similajau National Park	BINTULU	7,064.0	0.0	7,064.0	20.04.1978	01.12.1976	77.7
	Similajau National Park Extension 1	BINTULU	1,932.0	0.0	1,932.0	22.06.2000	20.04.2000	20.4
15.	Bukit Tiban National Park	BINTULU	8,000.0	0.0	8,000.0	31.05.2000	17.02.200	50.2
16.	Gunong Mulu National Park	MIRI	52,865.0	0.0	52,865.0	03.10.1974	01.08.1974	136.5
	Gunung Mulu National Park Extension 2	MIRI	28,530.0	0.0	28,530.0	09.06.2011	20.01.2011	
17.	Niah National Park	MIRI	3,138.0	0.0	3,138.0	23.01.1975	23.11.1974	29.8
18.	Lambir Hills National Park	MIRI	6,949.0	0.0	6,949.0	15.05.1975	15.05.1975	52.4
19.	Loagan Bunut National Park	MIRI	10,736.0	0.0	10,736.0	29.08.1991	01.07.1990	69.5
20.	Usun Apau National Park	MIRI	49,355.0	0.0	49,355.0	29.09.2005	18.05.2005	109.6
21.	Miri-Sibuti Coral Reefs National Park	MIRI	0.0	186,930.0	186,930.0	19.04.2007	28.02.2007	190.9
22.	Pulong Tau National Park	MIRI & LIMBANG	59,817.0	0.0	59,817.0	24.03.2005	18.12.2004	218.4
23.	Gunung Buda National Park	LIMBANG	6,235.0	0.0	6,235.0	18.01.1957	14.09.2000	57.0
	Gunung Buda National Park Extension 1	LIMBANG	5,072.0	0.0	5,072.0	09.06.2011	17.03.2011	
24.	Ulu Sebuyau National Park	SRI AMN + SAMARAHAN	18,287.0	0.0	18,287.0	01.01.2010	25.03.2010	103.8
25.	Bukit Mersing National Park	BINTULU	5,729.0	0.0	5,729.0	09.06.2011	15.12.2015	
Total area (ha)			**341,326.0**	**206,344.0**	**547,670.0**			

Continued...... **Appendix 1**

Protected Areas of Sarawak as of October 2012

No.	Nature Reserves	Division	Land Area (Ha)	Water Bodies (Ha)	Total Area (Ha)	Date of Gazette	With effective from	Boundary (Km)
1	Wind Cave Nature Reserve	KUCHING	6.16	0.0	6.16	04.11.1999	26.08.1999	0.90
2	Sama Jaya Forest Park (Stutong NR)	KUCHING	37.90	0.0	37.90	03.03.2000	30.12.1999	3.20
3	Semenggoh Nature Reserve	KUCHING	653.00	0.0	653.00	20.04.2000	17.02.2000	12.60
4	Bukit Sembiling Nature Reserve	LIMBANG	101.00	0.0	101.00	22.06.2000	20.04.2000	8.60
5	Bukit Hitam Nature Reserve	LIMBANG	147.00	0.0	147.00	22.06.2000	20.04.2000	5.50
Total Area (Ha)			**945.06**	**0.0**	**945.06**			30.80

Protected Areas of Sarawak as of October 2012

No.	Wildlife Sanctuaries	Division	Land Area (Ha)	Water Bodies (Ha)	Total Area (Ha)	Date of Gazette	With effective from	Boundary (Km)
1	Samunsam Wild Life Sanctuary	KUCHING	6,092.00	0.0	6,092.00		01.07.1978	39.10
	Samunsam Wild Life Sanctuary (1st Ext.)	KUCHING	16,706.00	0.0	16,706.00	03.08.2000	29.05.2000	62.50
2	Pulau Tukong Ara and Banun WS	KUCHING	1.40	0.0	1.40		28.02.1985	0.40
3	Lanjak Entimau Wild Life Sanctuary	SARIKEI,SIBU ,KAPIT	168,758.00	0.0	168,758.00		02.02.1983	301.80
4	Sibuti Wild Life Sanctuary	MIRI	678.00	0.0	678.00	03.08.2000	29.05.2000	7.20
Total Area (Ha)			**192,235.40**	**0.0**	**192,235.40**			**411.00**

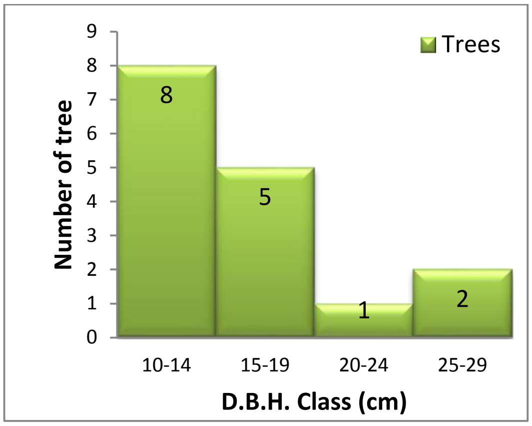
Appendix 2

Proboscis Monkey's locations in Borneo

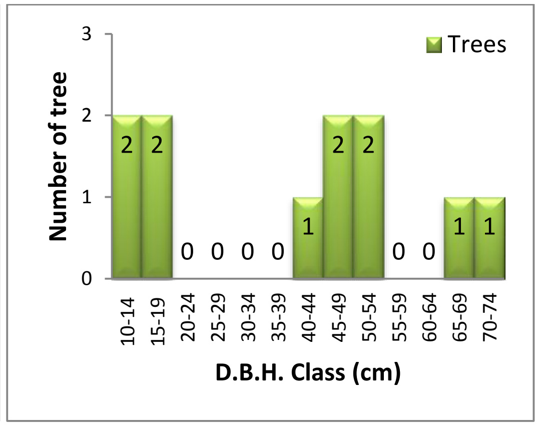
Sarawak	Latitude	Longitude
Bako National Park	1° 43' 0"	110° 28' 0"
Pulau Lakei	1° 45' 0"	110° 28' 59"
Sungai Bako	1° 34' 0"	110° 31' 59"
Kampung Bako	1° 40' 0"	110° 25' 0"
SMK Bako		
Kampung Selabat		
Sungai Selabat	1° 40' 51"	110° 28' 55"
Kuching Wetland National Park		
Pulau Salak	1° 40' 0"	110° 16' 59"
Sungai Jebong Besar	1° 37' 59"	110° 19' 0"
Sungai Jebong Kechil	1° 37' 59"	110° 18' 0"
Sungai Jebong Api	1° 39' 0"	110° 16' 0"
Batang Semariang	1° 37' 59"	110° 16' 59"
Maludam National Park		
Maludam	1° 39' 0"	111° 1' 59"
Samunsam Wildlife Sanctuary	1° 78' N	109° 36' E
Kuala Lawas	4° 58' 0"	115° 24' 0"
Rejang Mangrove	2° 4' 59"	111° 16' 0"
Ulu Sebuyau National Park		
Sabah	Latitude	Longitude
Sukau, Kinabatangan River	5° 30' N	118° 30' E
Abai, Kinabatangan River	5° 41' N	118° 32' E
Padas Bay	5° 13' 0"	115° 34' 0"
Padas Damit Forest Reserve, Garama, Klias		
Padas Damit River	5° 16' 0"	115° 25' 59"
Sungai Klias	5° 18' 0"	115° 22' 0"
Menanggul River, Kinabatangan	5° 30' N	118° 30' E
Kalimantan Indonesia	Latitude	Longitude
Tanjung Puting National Park		
Tanjung Puting, Kalimantan Tengah	-3° 31' 0"	111° 46' 0"
Danau Sentarum Wildlife Reserve	0° 51' 0"	112° 6' 0"
Kutai National Park		
Sungai Kutai	-0° 34' 59"	117° 16' 59"
Mahakam Lakes		
Mahakam River	-0° 34' 59"	117° 16' 59"
Mahakam Delta		
South Mahakam		
Central Kalimantan River		
Lower South Barito		
Sungai Barito	-3° 31' 59"	114° 28' 59"
Sambas Paloh Nature Reserve		
Sungai Paloh	1° 45' 0"	109° 16' 59"
Sangkulirang		
Sangkulirang Bay	0° 49' 59"	118° 4' 59"
Sungai Sangkulirang	1° 6' 0"	117° 54' 0"
Sesayap, Sebuku & Sembakung		
Sungai Sesayap	3° 36' 0"	117° 15' 0"
Sungai Sebuku	4° 3' 0"	117° 30' 0"
Sungai Sembakung	3° 46' 59"	117° 30' 0"

Sungai Kayan		
Balikpapan Bay		
Pulau Laut		
Kendawang		
Pulau Kaget		
Sungai Wain Protection Forest		
Gunung Palong National Park		
Brunei	Latitude	Longitude
Brunei Bay	5° 4' 59"	115° 18' 0"
Pulau Siarau	4° 48' 0"	115° 1' 59"
Sungai Brunei	4° 55' 0"	115° 0' 0"
Pulau Baru Baru	4° 54' 0"	115° 1' 59"
Berambung		
Pepatan		
Sungai Berbunut	4° 55' 59"	114° 55' 0"
Sungai Kaingaran	4° 58' 59"	114° 54' 0"
Ranggu		
Dolhakim		
Sungai Menunggul	4° 54' 0"	115° 1' 0"
Sungai Lumapas	4° 51' 0"	114° 54' 0"
Aloh Besar		
Sungai Damuan	4° 52' 0"	114° 51' 0"
Sungai Ayam Ayam	4° 52' 0"	115° 9' 0"
Sungai Bangau	4° 55' 0"	115° 9' 0"

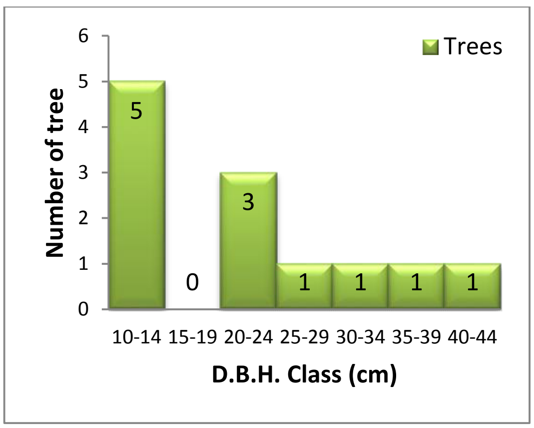
Appendix 3



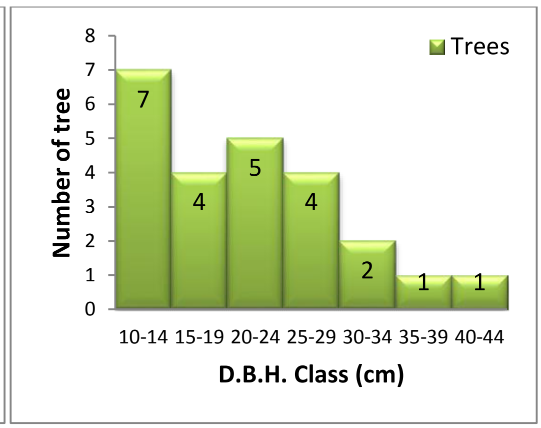
a. SU 1 at Paku Trail (BA=17.76 m²ha-¹) (circular plot)



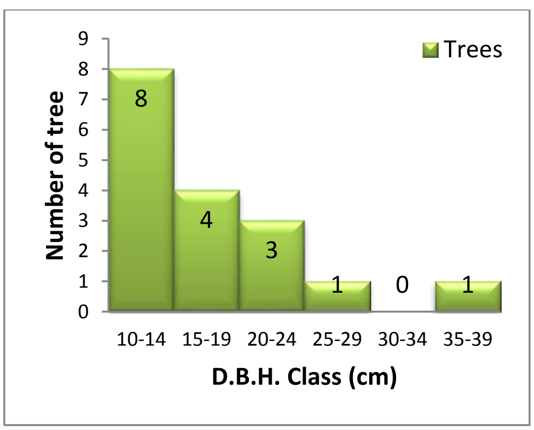
b. SU 2 at Lintang Trail (BA = 85.91 m²ha-¹) (linear plot)



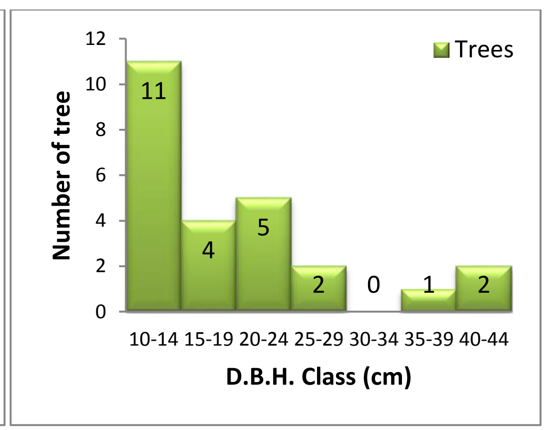
c.SU 3 (linear plot) at Lintang Trail (BA = 28.22 m²ha-¹)



d. SU 4 (linear plot) at Lintang Trail (BA =49.52 m²ha-¹)

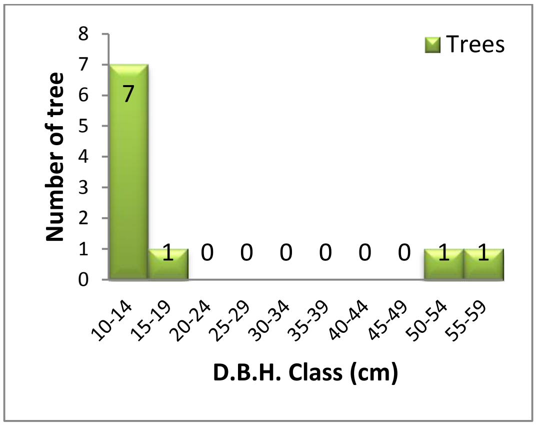


e. SU 5 (circular plot) at Lintang Trail (BA = 23.25 m²ha-¹)

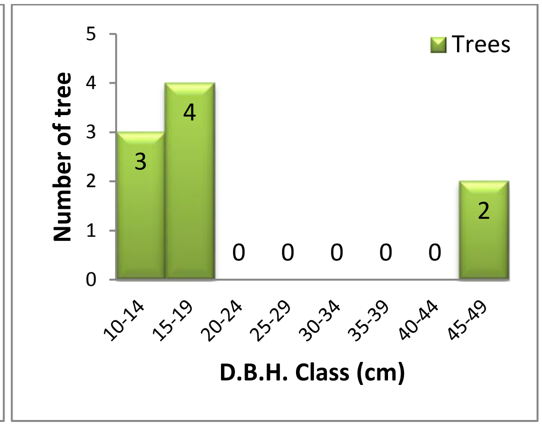


f. SU 6 (linear plot) at Lintang Trail (BA = 45.13 m²ha-¹)

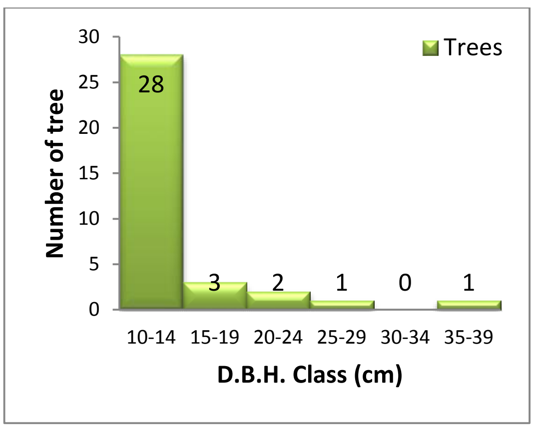
Continued ... **Appendix 3**



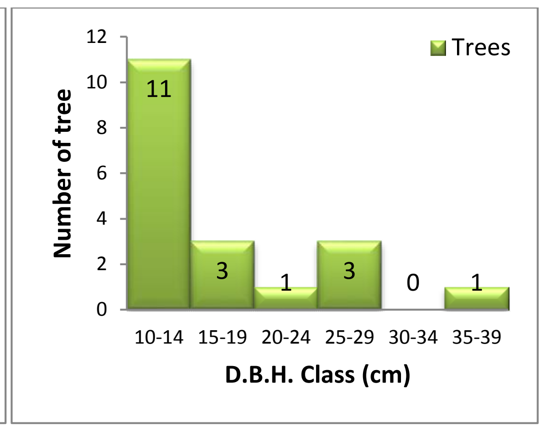
g. SU 7 (linear plot) at Paku Trail (BA = 27.61 m^2ha^{-1})



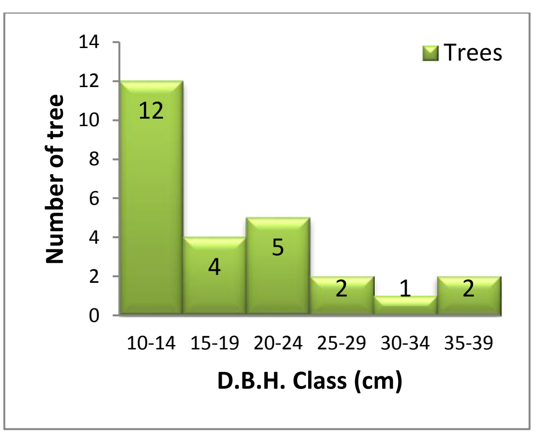
h. SU 8 (linear plot) at Paku Trail (BA = 24.16 m^2ha^{-1})



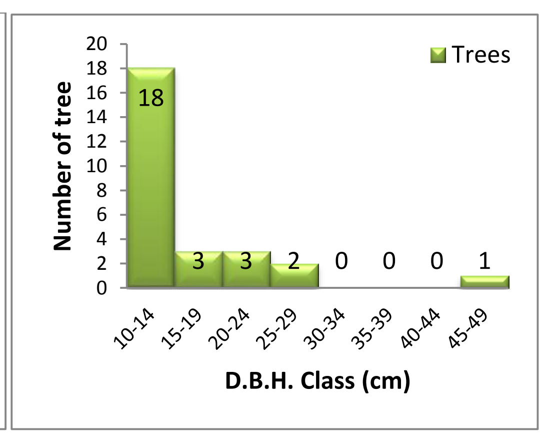
i. SU 9 (linear plot) at Tajor Trail (BA = 32.05 m^2ha^{-1})



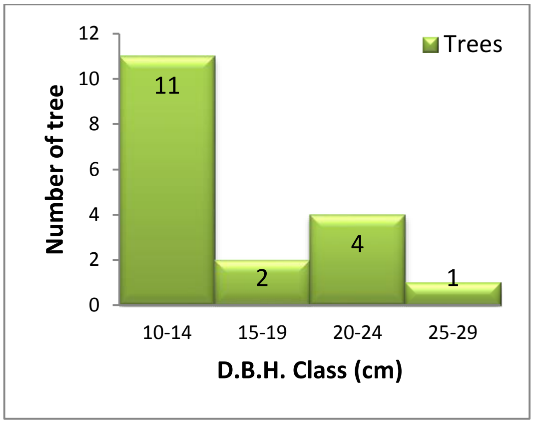
j. SU 10 (linear plot) at Tajor Trail (BA = 24.45 m^2ha^{-1})



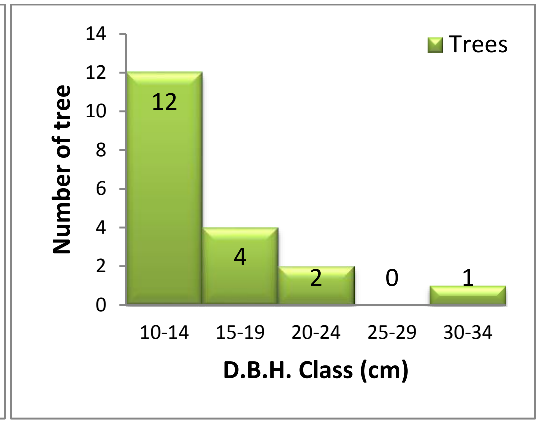
k. SU 11 (linear plot) at Tajor Trail (BA = 42.38 m^2ha^{-1})



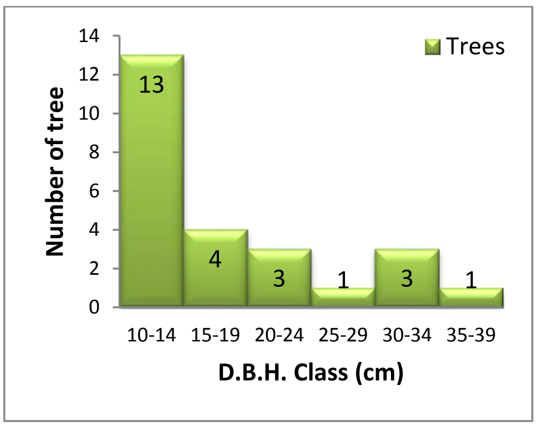
l. SU 12 (linear plot) at Sibur Trail (BA =32.48 m^2ha^{-1})



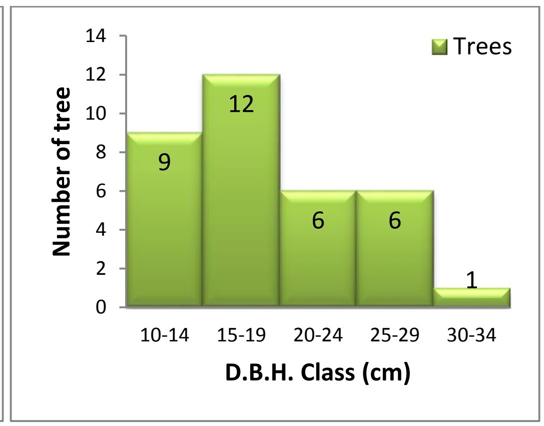
m. SU 13 (linear plot) at Sibur Trail (BA = 17.94 m^2ha^{-1})



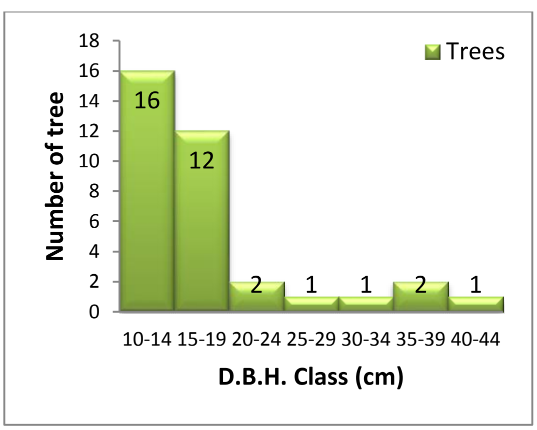
n. SU 14 (quadrat) at Paku Trail (BA = 9.72 m^2ha^{-1})



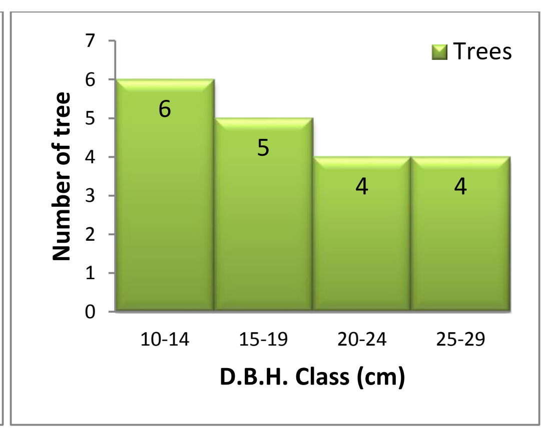
o. SU 15 (quadrat) at Lintang Trail (BA = 19.97 m^2ha^{-1})



p. SU 16 (quadrat) at Lintang Trail (BA = 26.15 m^2ha^{-1})

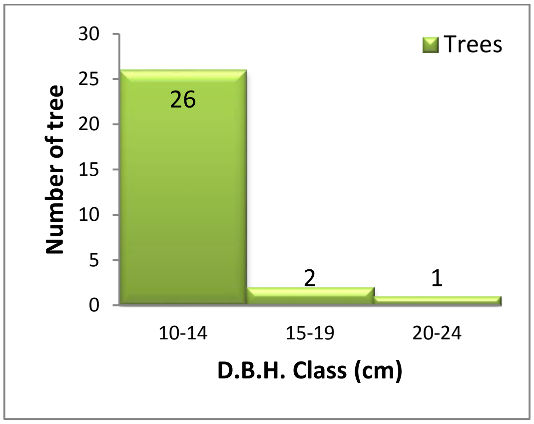


q. SU 17 (quadrat) at Lintang Trail (BA = 25.69 m^2ha^{-1})

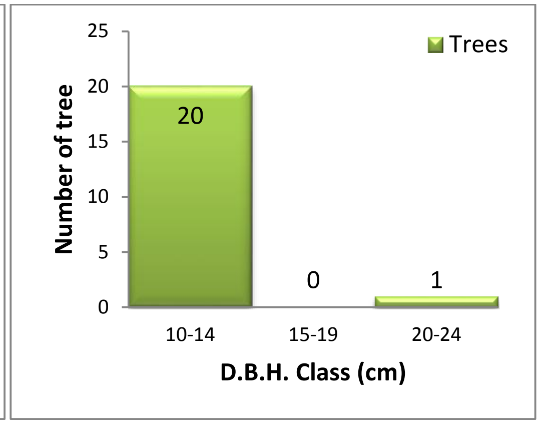


r. SU 18 (quadrat) at Lintang Trail (BA = 14.78 m^2ha^{-1})

D.B.H. class distribution of trees in medium closed heath forest

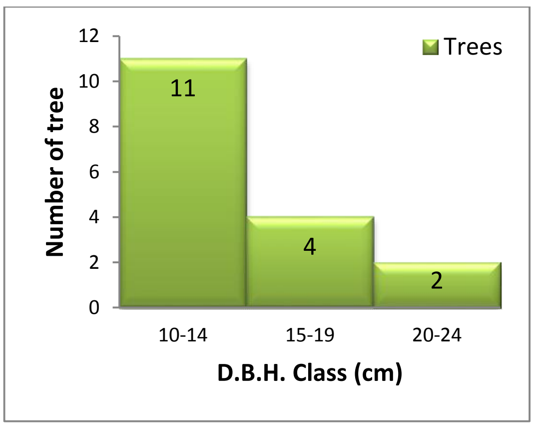


a. SU1 (circular plot) at Pak Amit Trail(BA = 19.83 m²ha-¹)

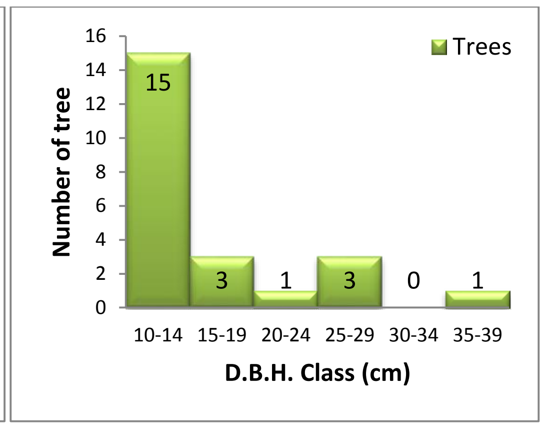


b. SU 2 (circular plot) at Pak Amit Trail(BA = 11.43 m²ha-¹)

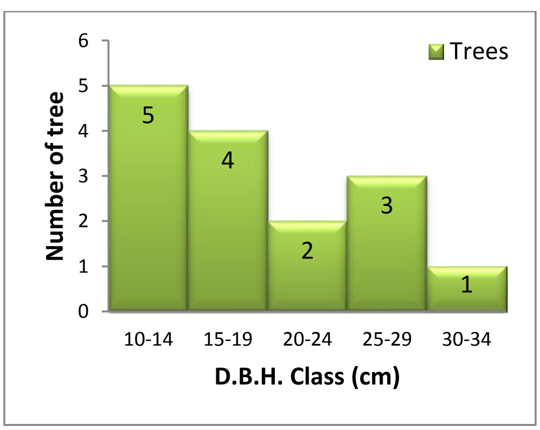
D.B.H. class distribution of trees in low closed heath forest



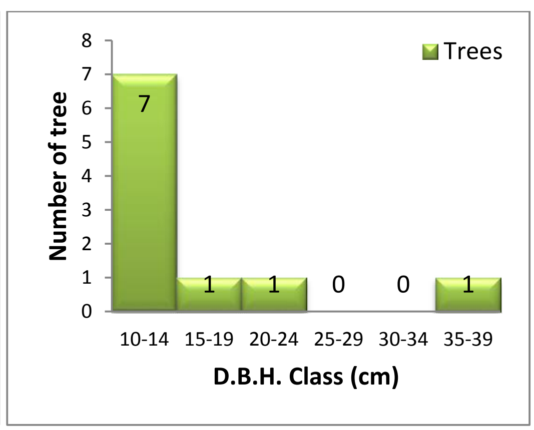
a. SU 1 (linear plot) at site 1 (BA = 12.69 m²ha-¹)



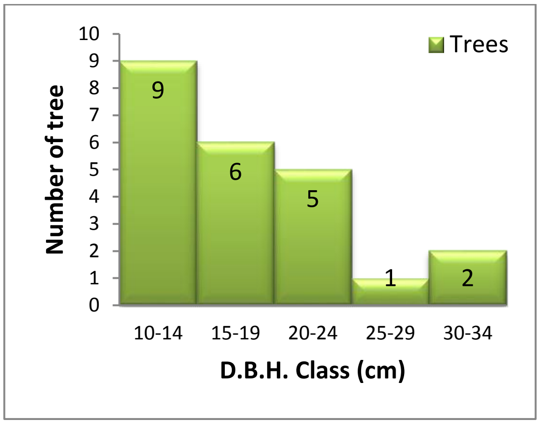
b. SU 2 (linear plot) at site 1 (BA = 25.05 m²ha-¹)



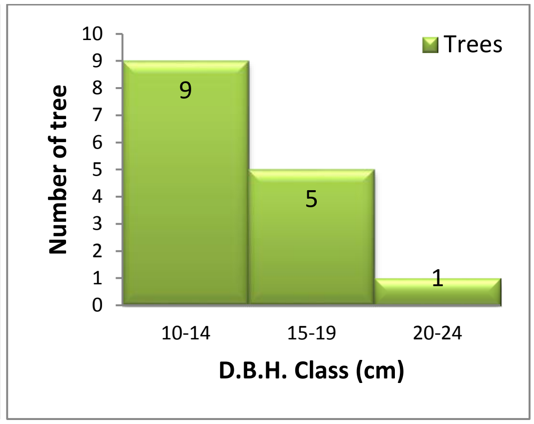
c. SU 3 (linear plot) at site 1 (BA = 22.17 m²ha-¹)



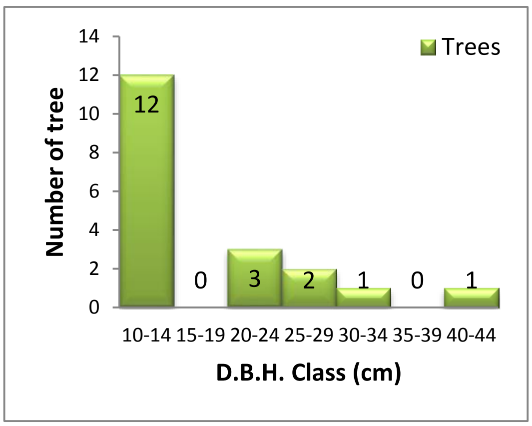
d. SU 4 (linear plot) at site 1 (BA = 12.68 m²ha-¹)



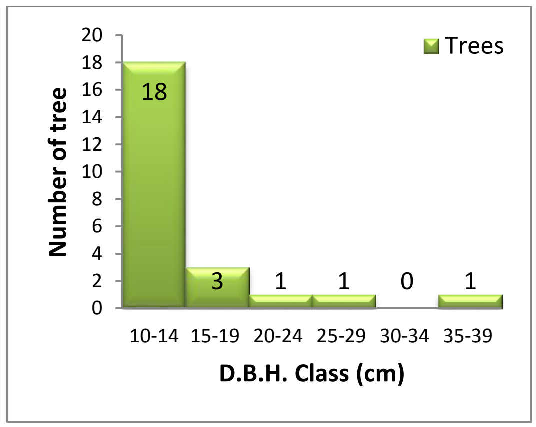
e. SU 5 (linear plot) at site 1 (BA = 33.38 m^2ha^{-1})



f. SU 6 (linear plot) at site 2 (BA = 12.95 m^2ha^{-1})



g. SU 7 (linear plot) at site 2 (BA = 29.77 m^2ha^{-1})



h. SU 8 (linear plot) at site 2 (BA = 21.85 m^2ha^{-1})

D.B.H. class distribution of trees in flooded forest

Appendix 4

Species list recorded at heath forest in Bako National Park and Kuching Wetland National Park

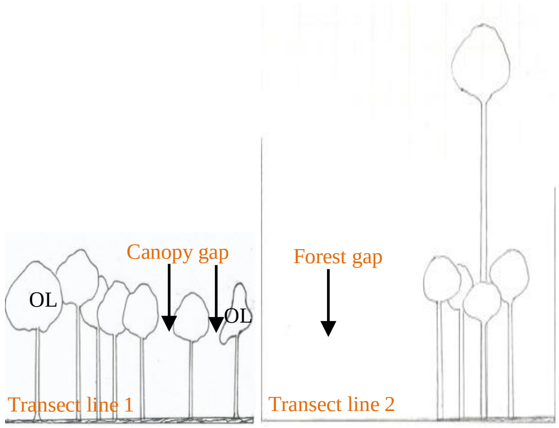
Species names	Source of food plants obtained		
	Literature	This study	Local people
Aetoxylon sympetalum Airy shaw.			
Amoora sp.			
Aporusa miqueliana *Muell.-Arg.*			
Artocarpus elasticus	√		
Blumeodendron sp.			
Calophyllum biflorum Hend.&W.Sm.			
Calophyllum hosei			
Calophyllum lanigerum var. austrocoriaceum		√	
Calophyllum sp.	√		√
Canarium sp.	√		
Canthium didymun *Gaertn. f.*			
Canthium umbelligerum Miq.		√	
Cantleya sp.			
Cotylelobium burckii *(Hein.) Hein.*		√	
Cotylelobium melanoxylon (Hook.f.) Pierre	√		
Cotylelobium sp.			√
Cratoxylum arborescens			
Cratoxylum glaucum Korth.			
Cratoxylum sp.	√		
Dacrydium sp.			
Dacryodes sp.			
Dialium indum Var Bursa	√		
Dialium sp.	√		
Dillenia sp.	√		
Diospyros rigida Hiern.			
Diospyros sp.	√		
Dipterocarpus borneensis			
Dipterocarpus nudus *Vesq.*		√	
Dipterocarpus sarawakensis *V. Sl.*			
Dipterocarpus sp.	√		
Dryobalanops beccarii			
Dryobalanops sp.	√		
Dyera sp.			
Elaeocarpus sp.	√		
Garcinia bancana Miq.		√	
Garcinia cuneifolia Pierre		√	
Garcinia cuspidata *King*			
Garcinia forbessi			
Garcinia penangiana Pierre		√	
Garcinia parvifolia *Miq.*	√		
Garcinia sarawahensis			
Garcinia sp.	√		√
Gluta aptera *(King) Ding Hou.*			

Gluta beccarii			
Gluta sp.			
Goniothalamus malayanus	√		
Gymnostoma nobile Johnson (msc.)	√		
Hopea dyeri *Heim*			
Hopea latifolia Sym. (Luis)			
Ixonanthes beccarii *Hall.*			
Ixonanthes reticulate Jack.			
Koompassia malaccensis			
Koompassia sp.			
Litsea accedens var. accedens			
Litsea sp.	√	√	
Mangifera sp.	√		
Melanorrhoe sp.			
Memecylon sp.	√		
Mezzettia leptopoda (Hk.f. & Th.) Oliv.			
Myristica lowiana King		√	
Nephelium sp.			
Oncosperma tigillaria Ridl.		√	√
Palaquim gutta *(Hook.) Burck.*		√	
Palaquium microphyllum			
Palaquium rostratum			
Palaquium rufolanigerum		√	
Palaquium sp.	√		√
Palaquium walsuraefollum	√		
Parinari oblongifolia *Hook.f.*			
Parishia maingayi *Hook.f.*		√	
Payena sp.			
Pentace rigida Kostermans		√	
Phoebe opaca			
Ploiarium alternifolium		√	√
Polyalthia glauca			
Polyalthia hookeriana King			
Pternandra coerulescens Jack			√
Santiria oblongifolia			
Santiria sp.			
Sarcotheca diversifolia (Miq.) Hall			
Shorea acuta Ashton			
Shorea delbata *Foxw.*			
Shorea ovate			
Shorea sp.	√		√
Shorea stenoptera			
Shorea parvifolia			
Shorea retusa			
Sindora beccariana			
Stemonurus sp.			
Stemonurus umbellatus *Becc.*			
Syzygium cloraniha Duthie		√	
Syzygium multibracteolata merr.		√	
Syzygium rejangense M.& P.		√	

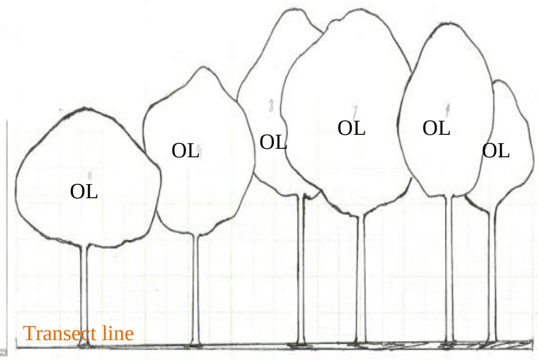
Syzygium sp.	√	√	√
Tetractomia tetrandra *(Roxb.) Merr.*			
Tristaniopsis sp.			√
Tristiropsis whitiana Griff.		√	
Vatica coriacea			
Vatica parvifolia			
Vatica sp.	√		
Vatica umbonata	√		
Vitex pubescens Vahl		√	√
Whiteodendron moultonianum *(W.W.Sm.) V.Steen.*		√	
Xanthophyllum sp.			
Xylopia ferruginea Hk.f.& Th.		√	
Xylopia fusca Maingay		√	
Xylopia sp.			√

√ equal to yes

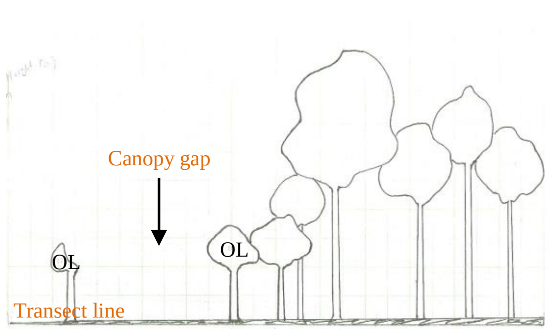
Appendix 5



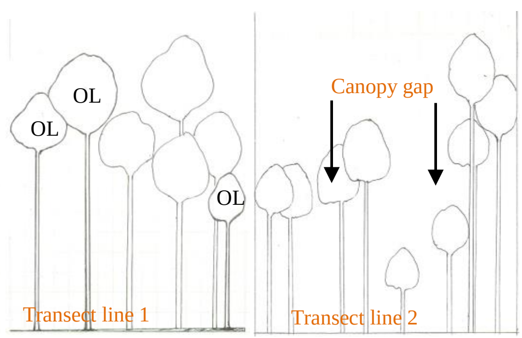
a. SU 1 at Paku Trail (OL – trees on transect line)



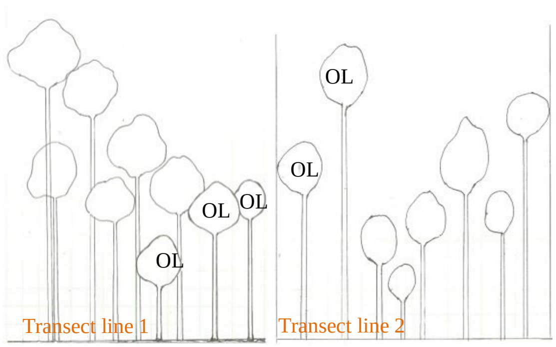
b. SU 2 at Lintang Trail (OL – trees on transect line)



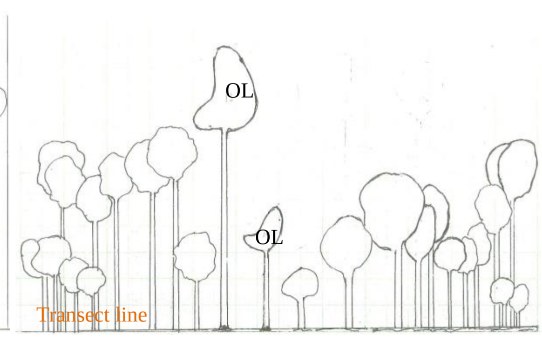
c. SU 3 at Lintang Trail (OL – Tree on transect line)



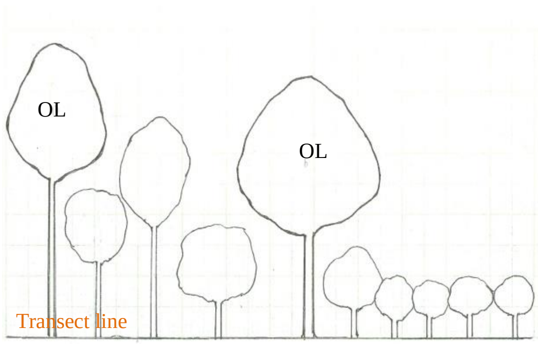
d. SU 4 at Lintang Trail



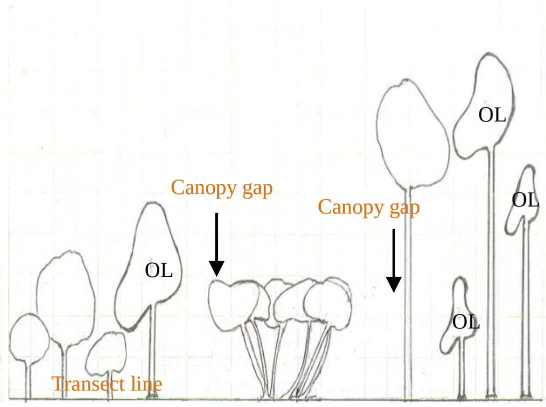
e. SU 5 at Lintang Trail (OL – Tree on transect line)



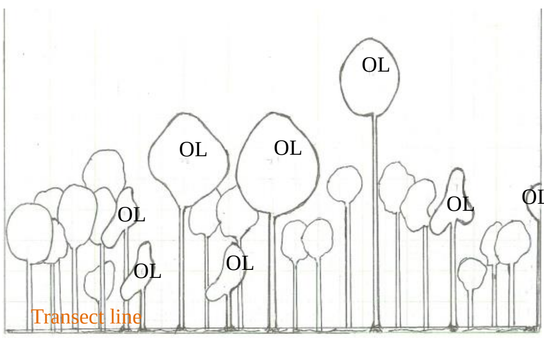
f. SU 6 at Lintang Trail (OL – Tree on transect line)



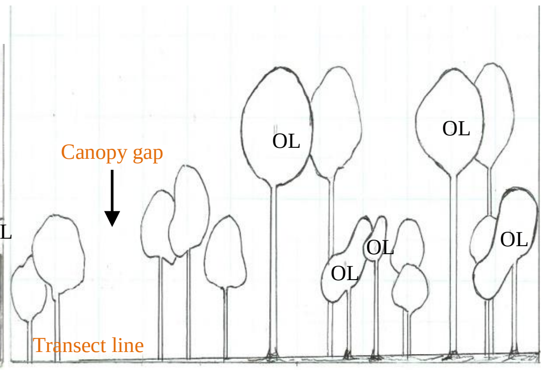
g. SU 7 at Paku Trail (OL – Tree on transect line)



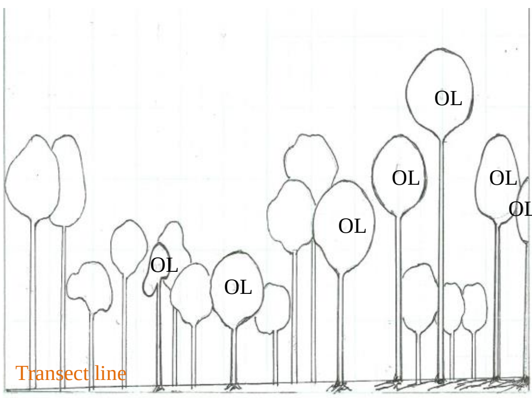
h. SU 8 at Paku Trail (OL – Tree on transect line)



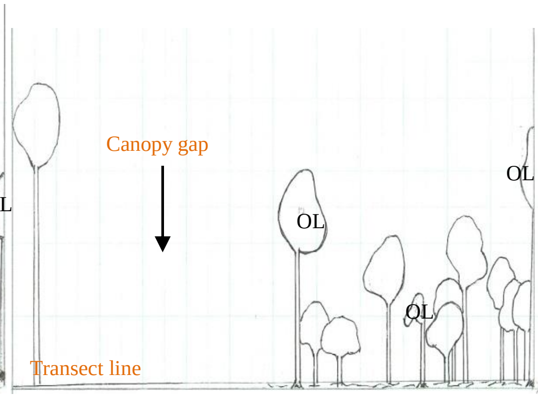
i. SU 9 at Tajot Trail (OL – Tree on transect line)



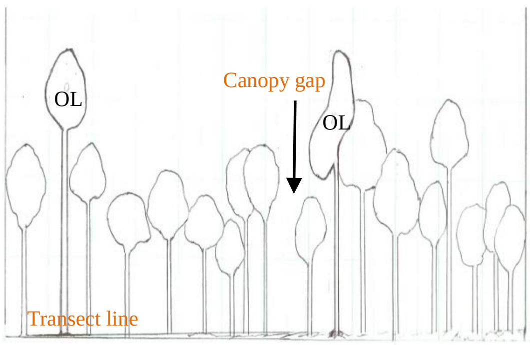
j. SU 10 at Tajor Trail (OL – Tree on transect line)



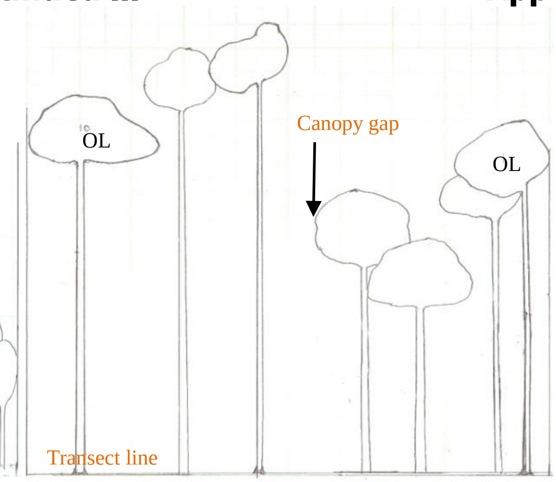
k. SU 11 at Tajor Trail (OL – Tree on transect line)



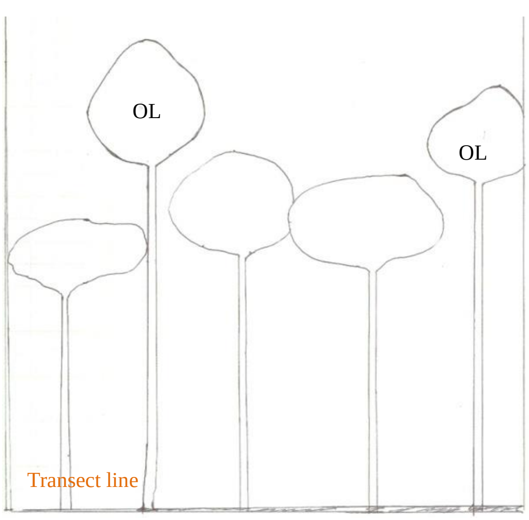
l. SU 12 at Sibur Trail (OL – Tree on transect line



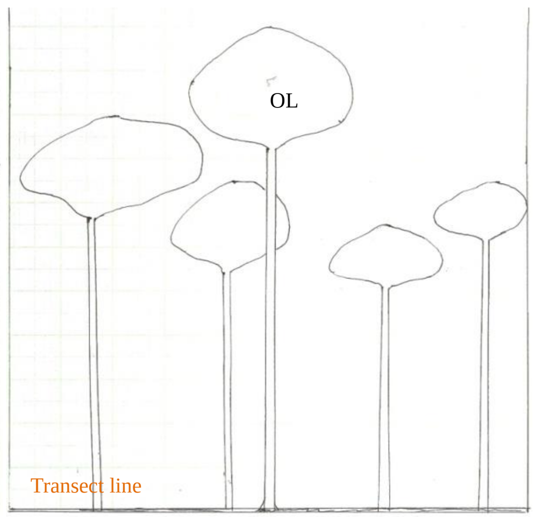
m. SU 13 at Sibur Trail (OL – Tree on transect line)



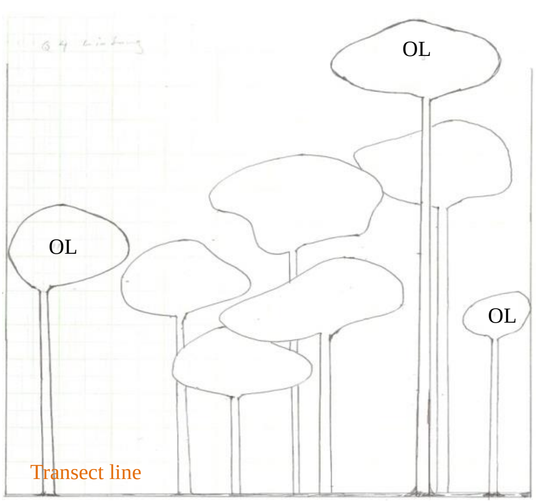
n. SU 14 at Paku Trail (OL – Tree on transect line)



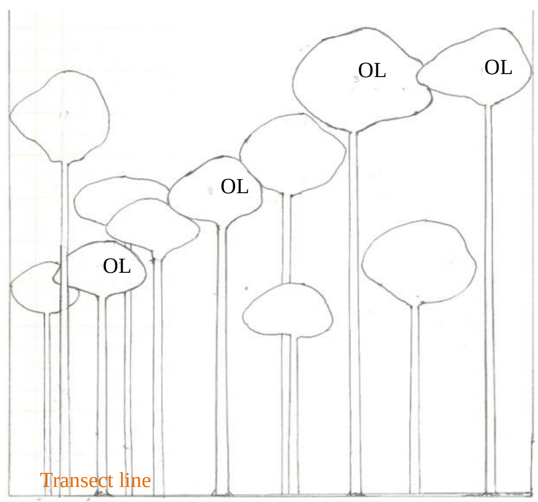
o. SU 15 at Lintang Trail (OL – Tree on transect line)



p. SU 16 at Lintang Trail (OL – Tree on transect line)



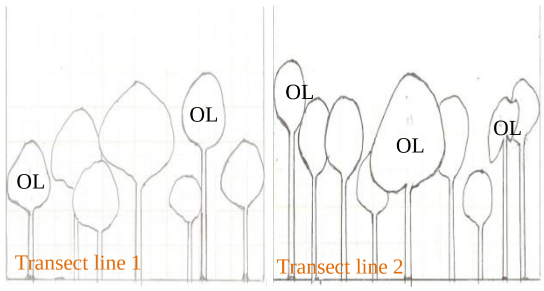
q. SU 17 at Lintang Trail (OL – Tree on transect line)



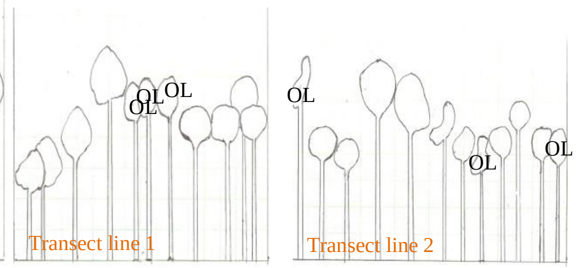
r. SU 18 at Lintang Trail (OL – Tree on transect line)

Profile of stands in medium closed heath forest

Continued ... **Appendix 5**

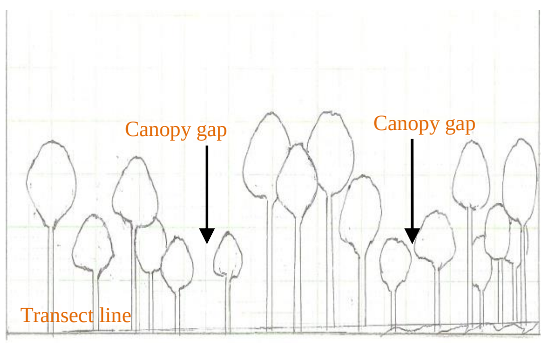


a. SU 1 at Pak Amit Trail (OL – Tree on transect line)

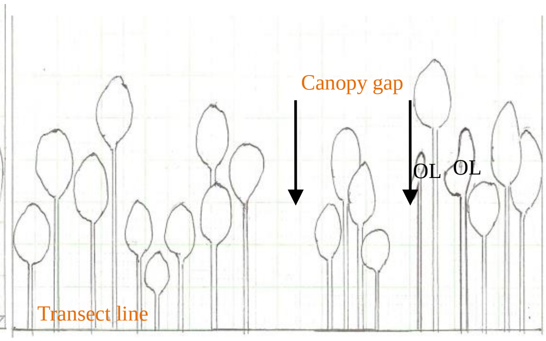


b. SU 2 at Pak Amit Trail (OL – Tree on tranect line)

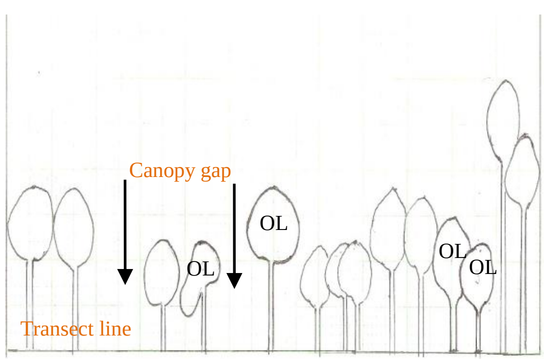
Profile of stands in low closed heath forest



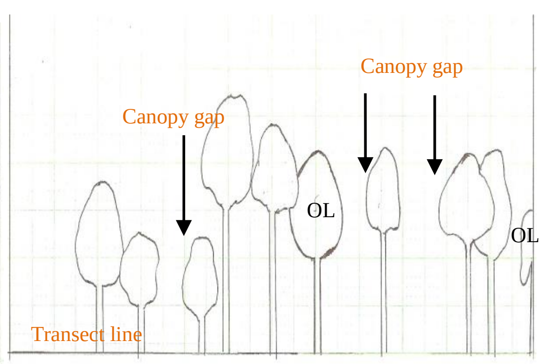
a. SU 1 at site 1



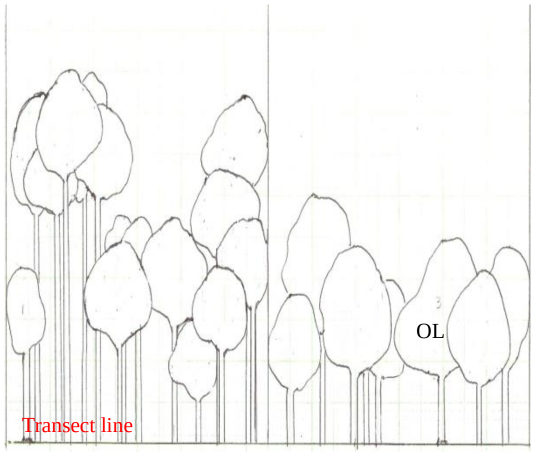
b. SU 2 at site 1 (OL – Tree on transect line)

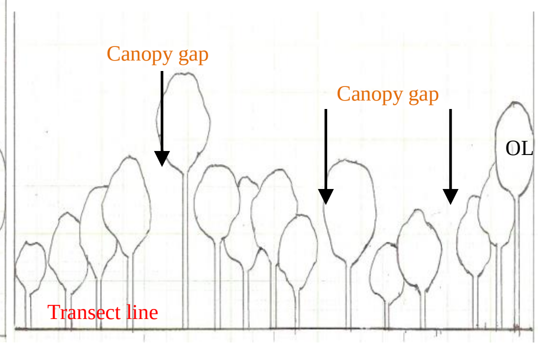


c. SU 3 at site 1 (OL – Tree on transect line)

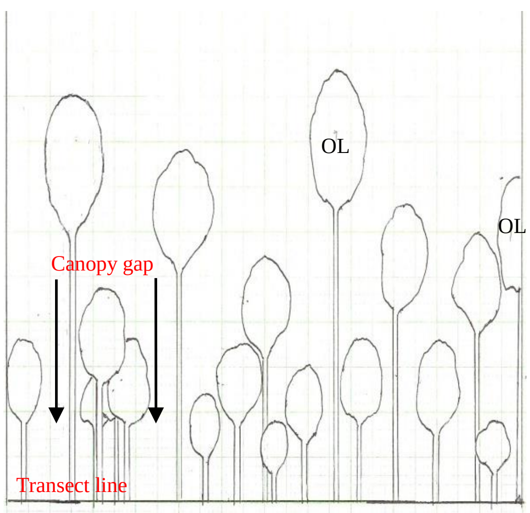


d. SU 4 at site 1 (OL – Tree on transect line)

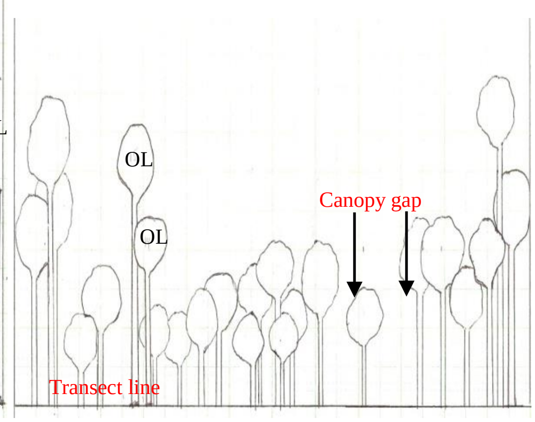




e. SU 5 at site 1 (OL – Tree on transect line)f. SU 6 at site 2 OL – Tree on transect line



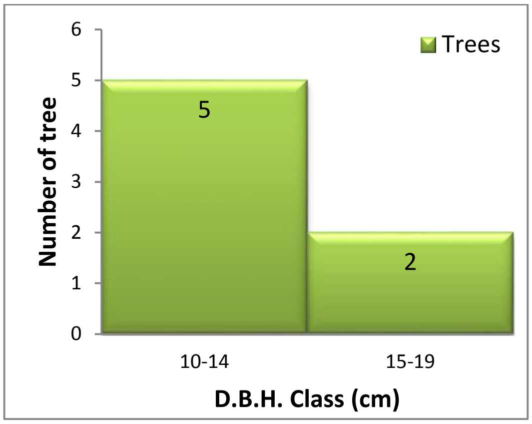
g. SU 7 at site 2 (OL – Tree on transect line)

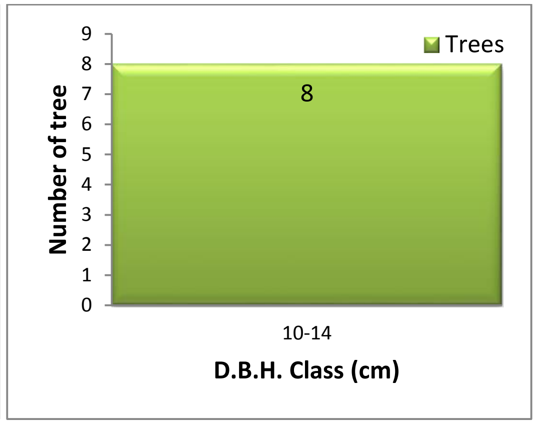


h. SU 8 at site 2 (OL – Tree on transect line)

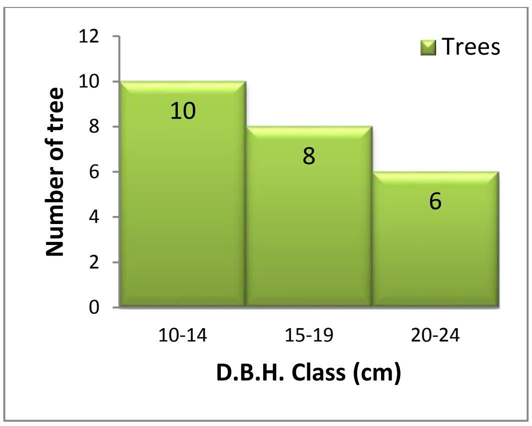
Profile of stands in flooded forest

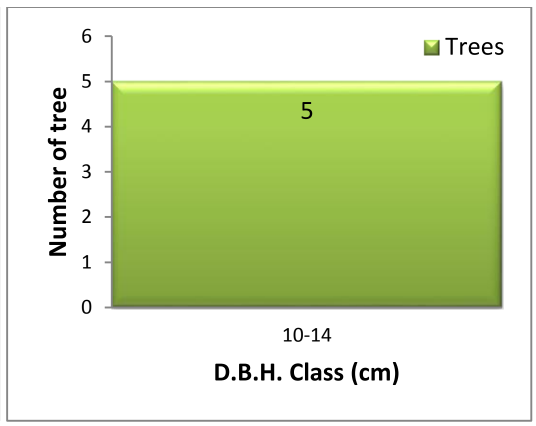
Appendix 6





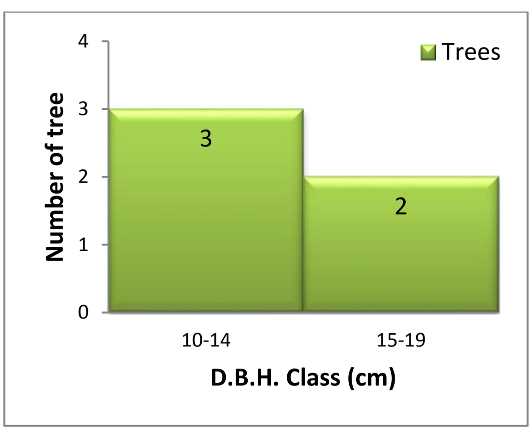
a. SU 1 (quadrat) at Teluk Assam (BA = 2.09 m²ha-¹)b. SU 2 (quadrat) at Teluk Assam (BA = 2.05 m²ha-¹)

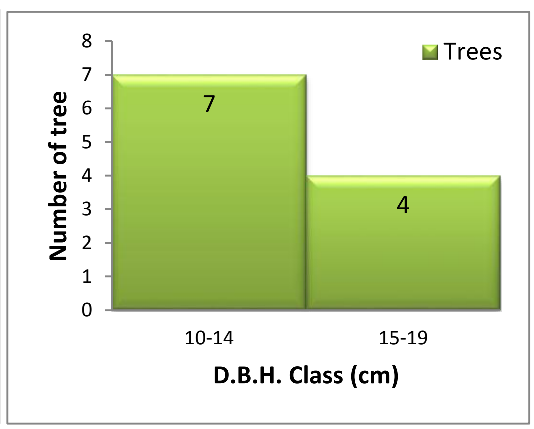




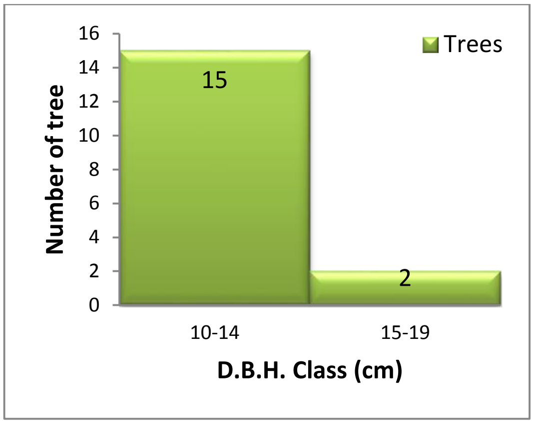
c. SU 3 (quadrat) at Teluk Assam (BA = 13.16 m²ha-¹)

d. SU 4 (quadrat) at Teluk Assam (BA = 1.24 m²ha-¹)

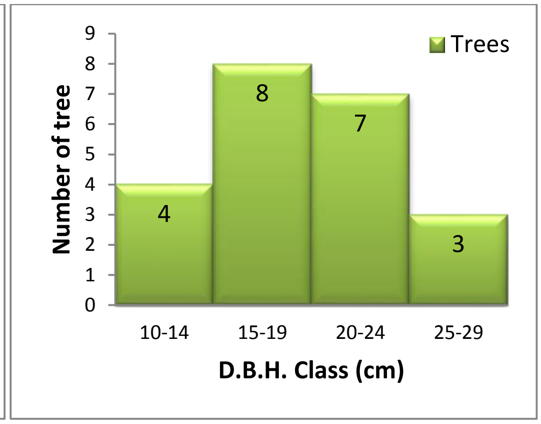




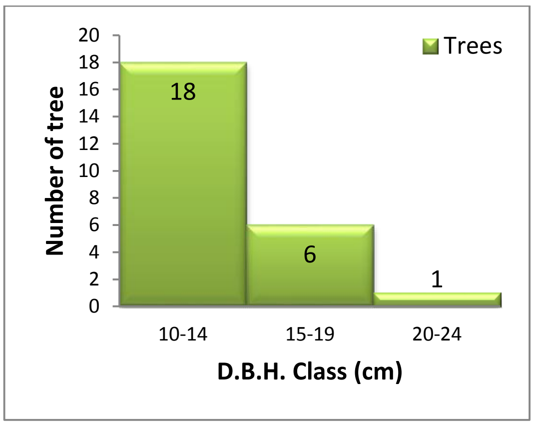
e. SU 5 (quadrat) at Teluk Assam (BA = 1.85 m²ha-¹)f. SU 6 (quadrat) at Teluk Delima (BA = 4.17 m²ha-¹)



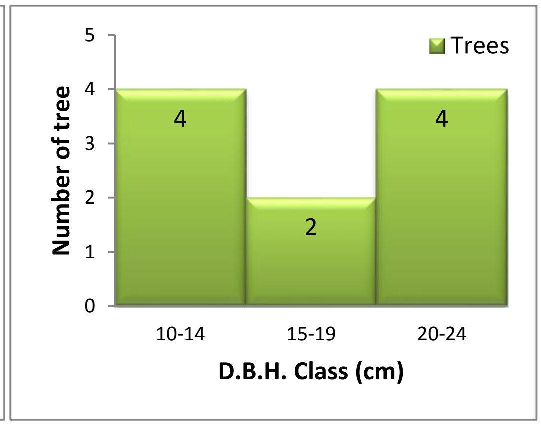
g. SU 7 (quadrat) at Teluk Delima (BA = 5.17 m²ha-¹)



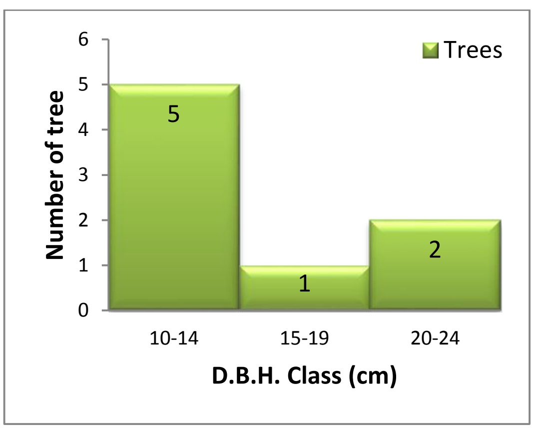
h. SU 8 (quadrat) at Teluk Delima (BA = 16.87 m²ha-¹)



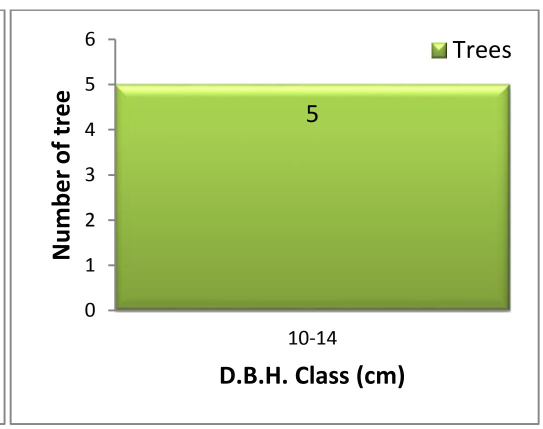
i. SU 9 (quadrat) at Teluk Delima (9.79 m²ha-¹)



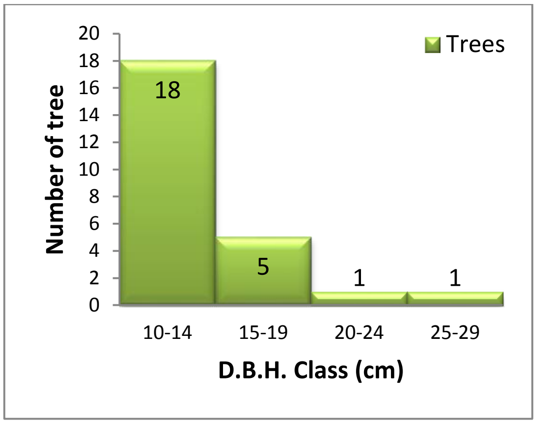
j. SU 10 (quadrat) at Teluk Deima (BA = 5.99 m²ha-¹)



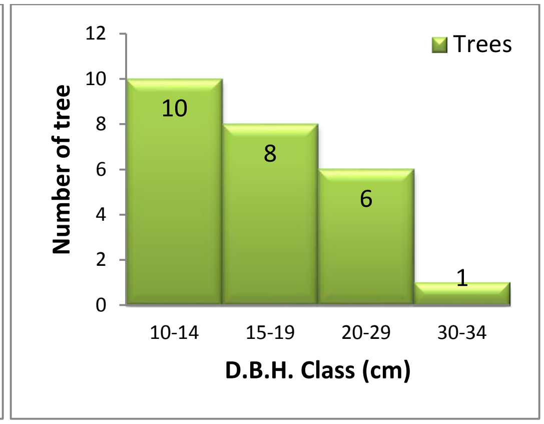
k. SU 11 (quadrat) at Teluk Delima (BA = 3.55 m²ha-¹)



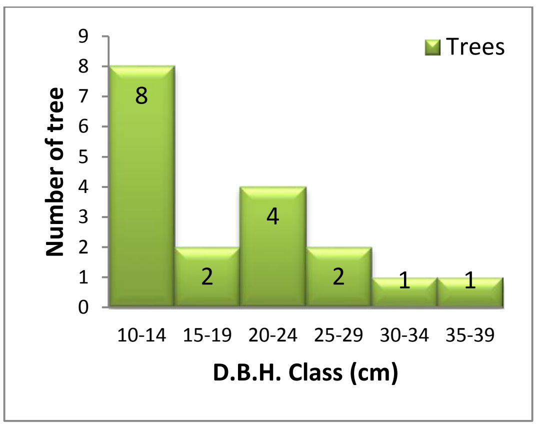
l. SU 12 (quadrat) at Teluk Delima (BA = 1.05 m²ha-¹)



m. SU 13 (quadrat) at Teluk Delima (BA = 10.27 m^2ha^{-1})

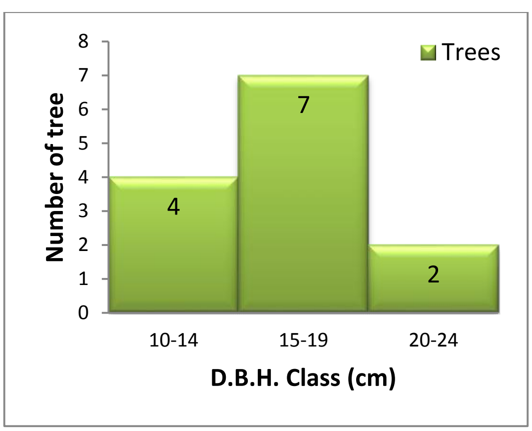


n. SU 14 (quadrat) at Teluk Delima (BA = 13.94 m^2ha^{-1})

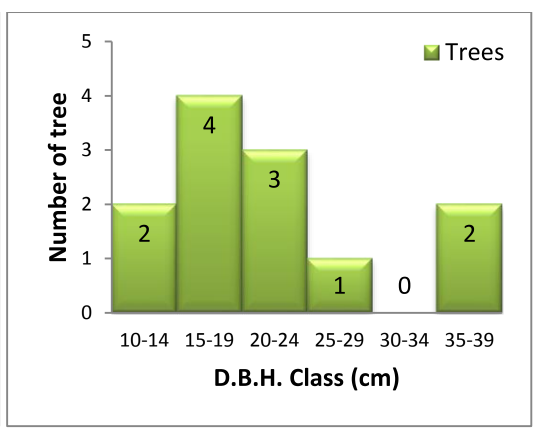


o. SU 15 (quadrat) at Teluk Delima (BA = 14.48 m^2ha^{-1})

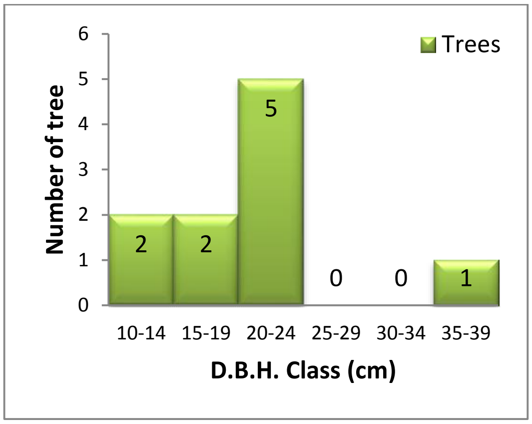
D.B.H. class distribution of trees in mangrove forest in Bako National Park



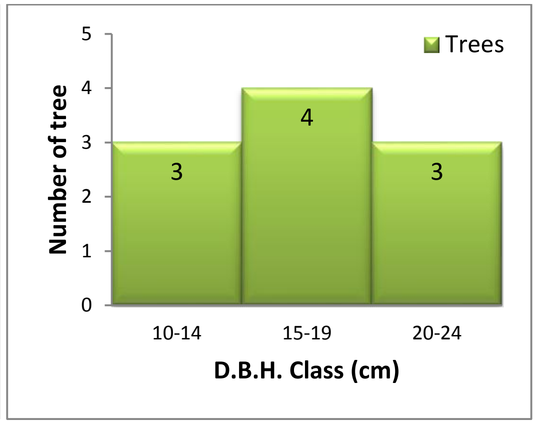
a. SU 1 (quadrat) at site 1 (BA = 7.33 m^2ha^{-1})



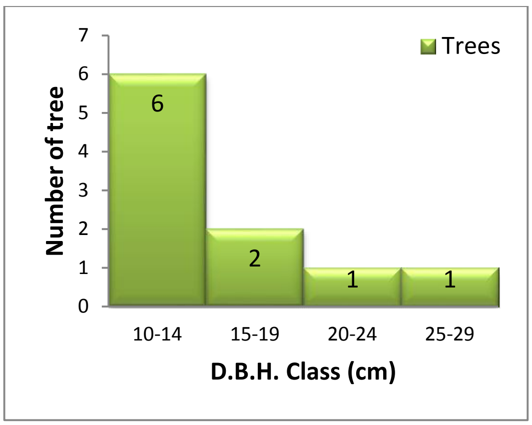
b. SU 2 (quadrat) at site 1 (BA = 12.81 m^2ha^{-1})



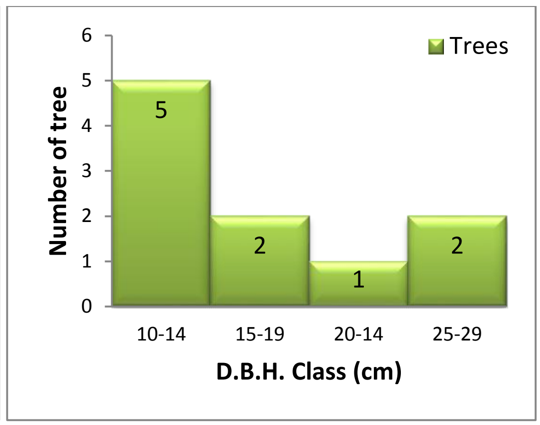
c. SU 3 (quadrat) at site 1 (BA = 8.88 m²ha-¹)



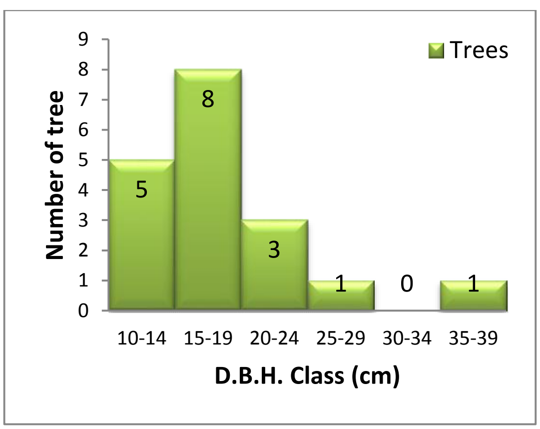
d. SU 4 (quadrat) at site 1 (BA = 5.85 m²ha-¹)



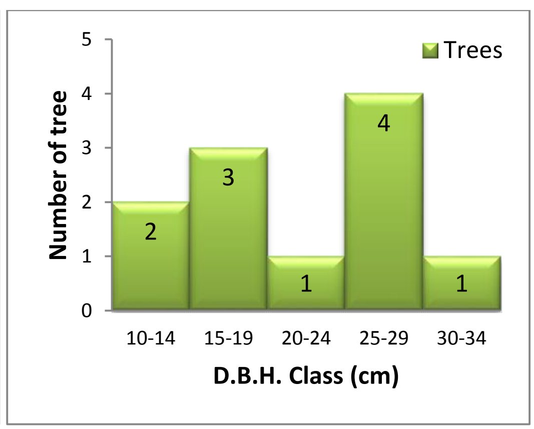
e. SU 5 (quadrat) at site 1 (BA = 4.87 m²ha-¹)



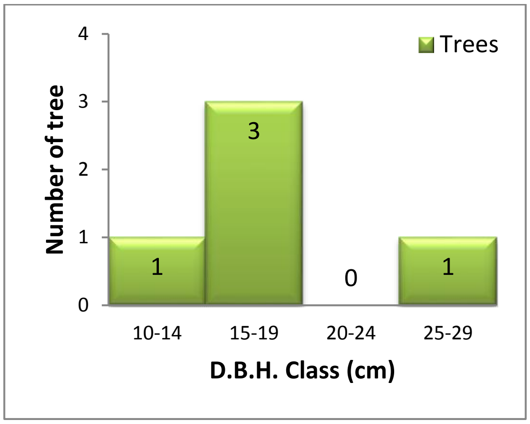
f. SU 6 (quadrat) at site 2 (BA = 6.19 m²ha-¹)



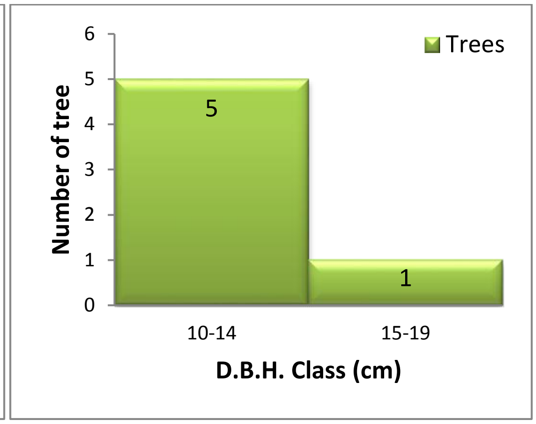
g. SU 7 (quadrat) at site 2 (BA = 13.48 m²ha-¹)



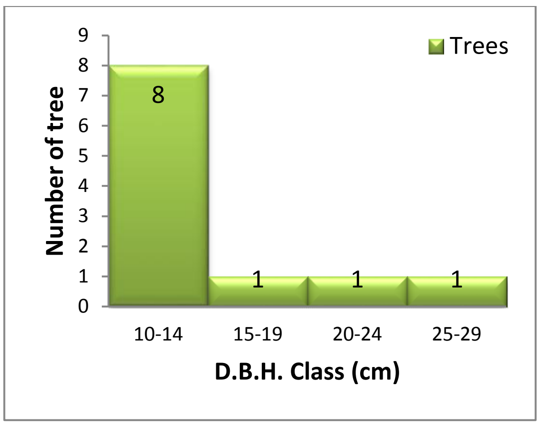
h. SU 8 (quadrat) at site 2 (BA = 12.74 m²ha-¹)



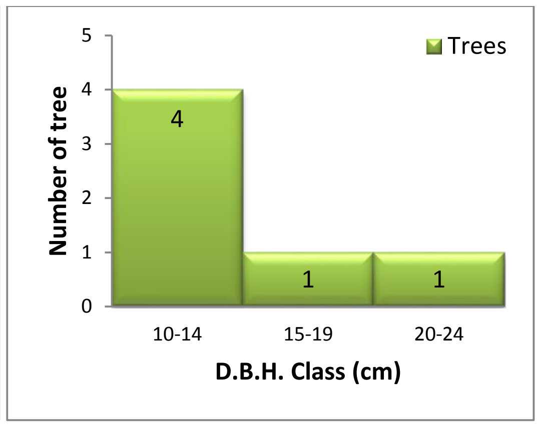
i. SU 9 (quadrat) at site 2 (BA = 3.57 m^2ha^{-1})



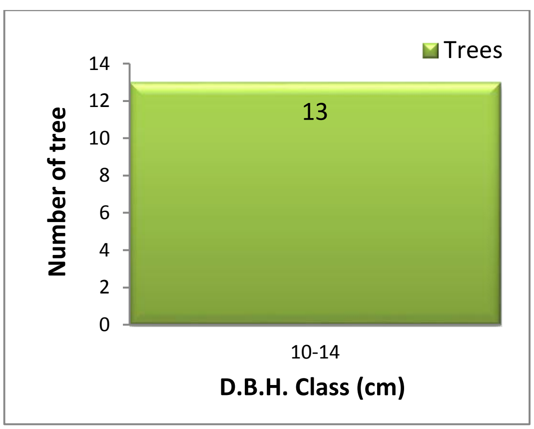
j. SU 10 (quadrat) at site 2 (BA = 2.16 m^2ha^{-1})



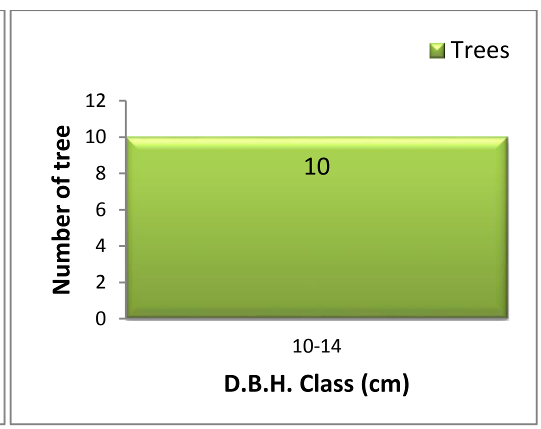
k. SU 11 (quadrat) at site 3 (BA = 5.33 m^2ha^{-1})



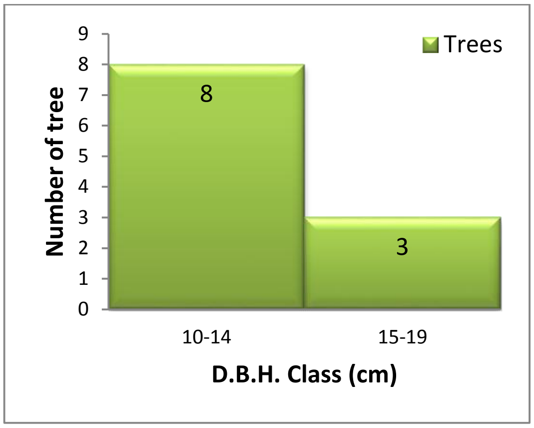
l. SU 12 (quadrat) at site 3 (BA = 2.34 m^2ha^{-1})



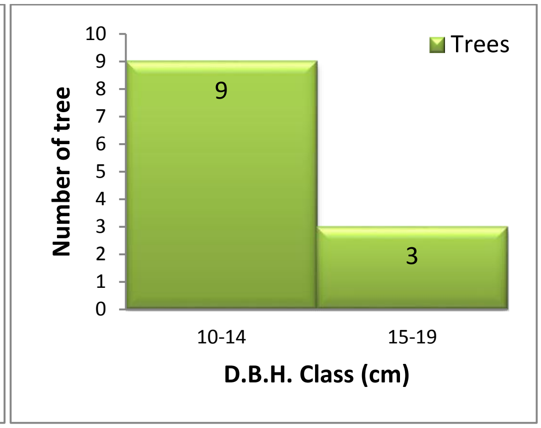
m. SU 13 (quadrat) at site 3 (BA = 3.33 m^2ha^{-1})



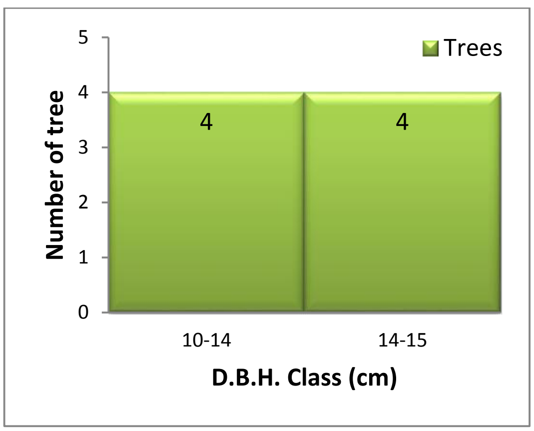
n. SU 14 (quadrat) at site 3 (BA = 2.77 m^2ha^{-1})



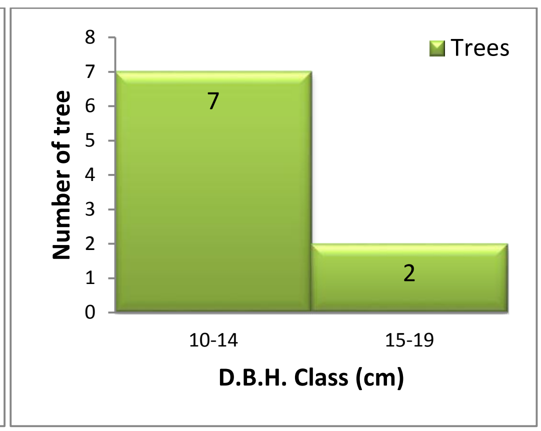
o. SU 15 (quadrat) at site 3 (BA = 3.48 m²ha-¹)



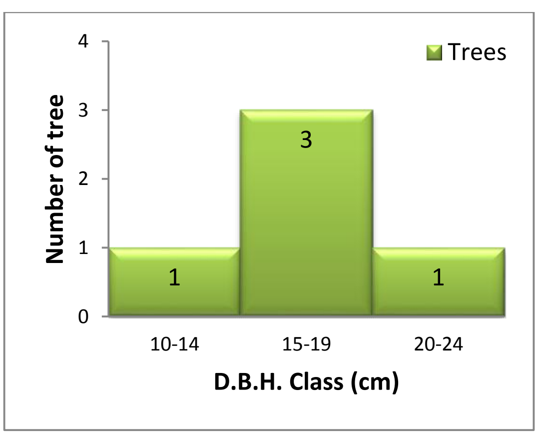
p. SU 16 (quadrat) at site 4 (BA = 4.00 m²ha-¹)



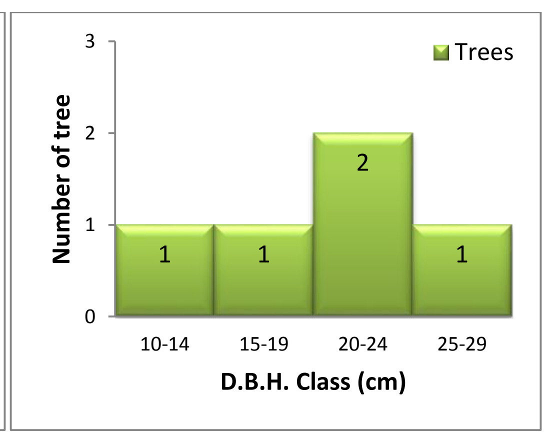
q. SU 17 (quadrat) at site 4 (BA = 3.29 m²ha-¹)



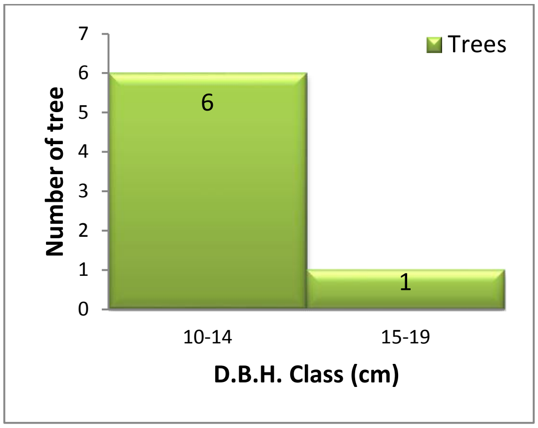
r. SU 18 (quadrat) at site 4 (BA = 3.12 m²ha-¹)



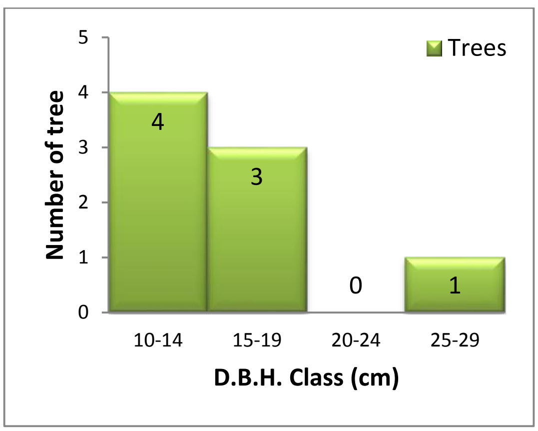
s. SU 19 (quadrat) at site 4 (BA = 2.53 m²ha-¹)

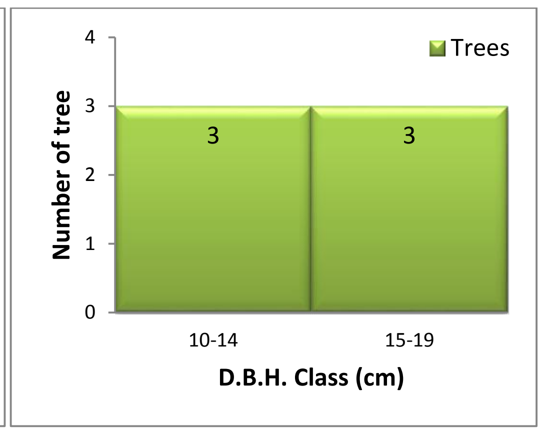


t. SU 20 (quadrat) at site 4 (BA = 3.78 m²ha-¹)

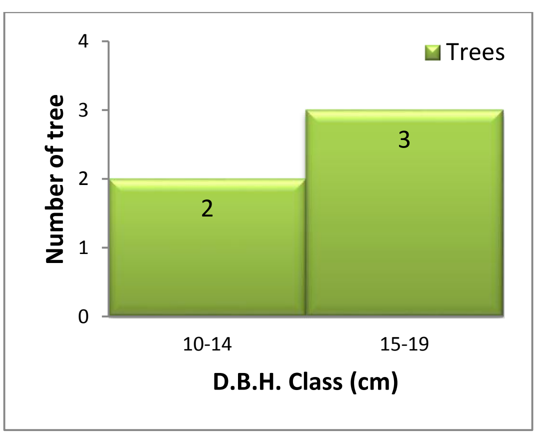


u. SU 21 (quadrat) at site 5 (BA = 2.57 m^2ha^{-1})v. SU 22 (quadrat) at site 5 (BA = 2.40 m^2ha^{-1})



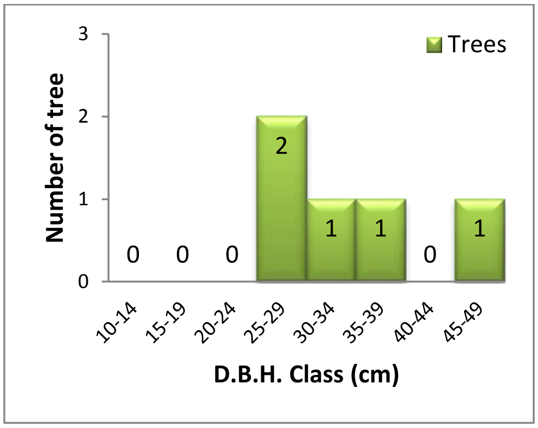


w. SU 23 (quadrat) at site 5 (BA = 4.20 m^2ha^{-1}) x. SU 24 (quadrat) at site 5 (BA = 2.69 m^2ha^{-1})

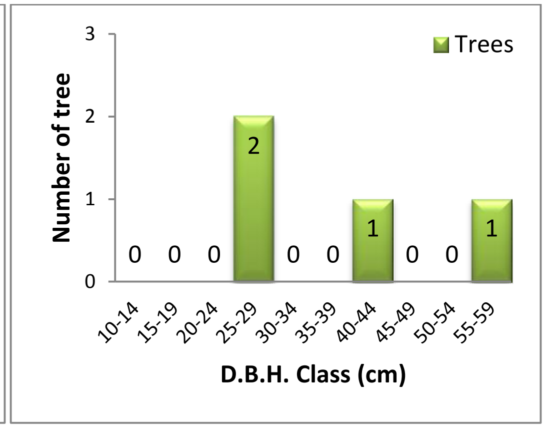


y. SU 25 (quadrat) at site 5 (BA = 2.29 m^2ha^{-1})

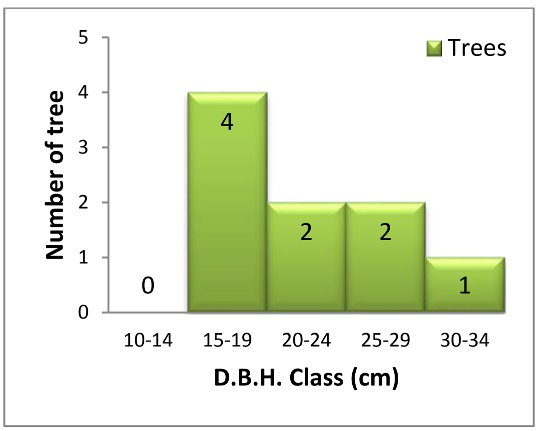
D.B.H. class distribution of trees in mangrove forest in Kuching Wetland National Park



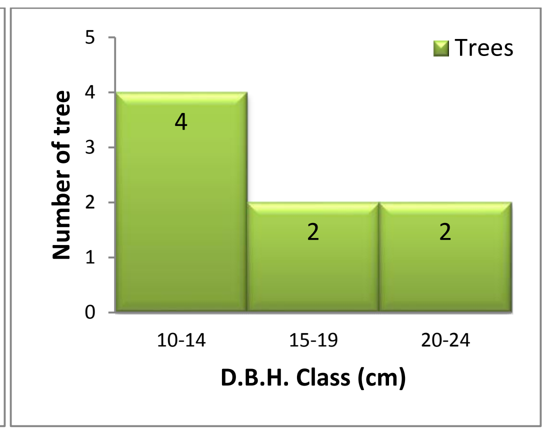
a. SU 1 (circular plot) at site 1 (BA = 24.12 m²ha-¹)



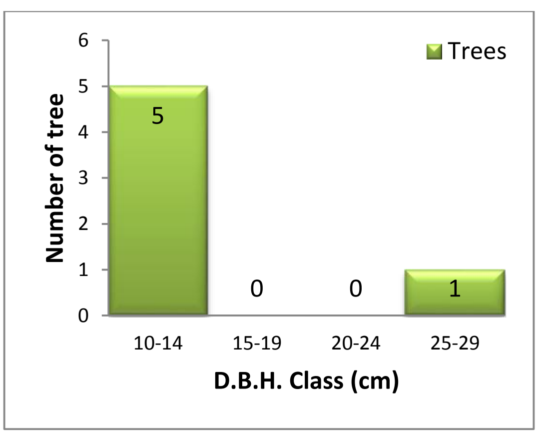
b. SU 2 (circular plot) at site 1 (BA = 26.08 m²ha-¹)



c. SU 3 (circular plot) at site 1 (BA = 18.71 m²ha-¹)

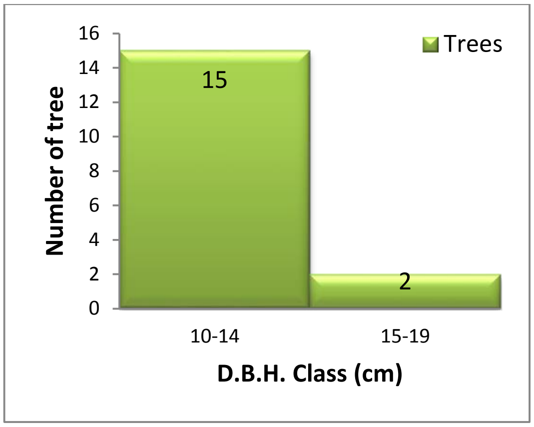


d. SU 4 (circular plot) at site 2 (BA = 8.34 m²ha-¹)



e. SU 5 (circular plot) at site 2 (BA = 6.03 m²ha-¹)

D.B.H. class distribution of trees in mangrove forest in Selabat



SU 1 (linear plot) behind Bako High School (BA = 9.37 m^2ha^{-1})

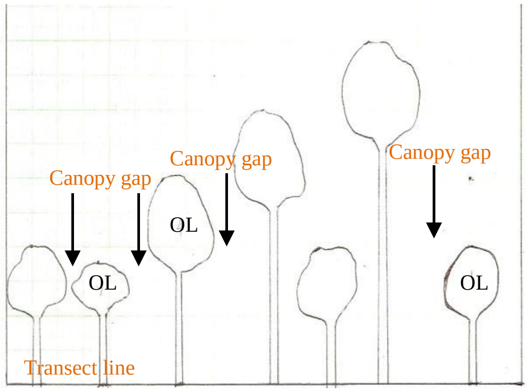
D.B.H. class distribution of trees in Bako High School mangrove

Appendix 7

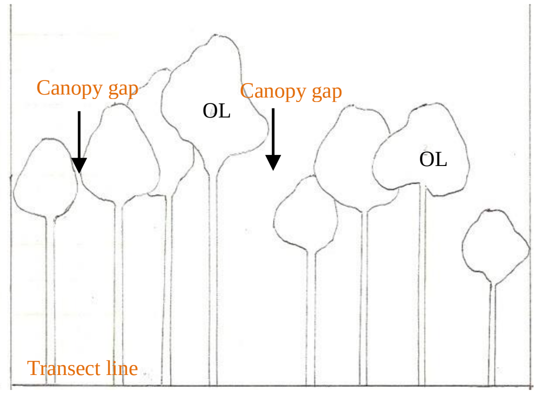
List of species in mangrove forests in Bako National Park, Kuching Wetland National Park, Selabat and Bako High School

Species names	Source of food plants obtained		
	Literature	This study	Local people
Avicennia alba	√	√	
Avicennia marina	√	√	
Avicennia sp.			
Bruguiera sp.	√		
Rhizophora apiculata	√	√	
Rhizophora mucronata	√	√	
Sonneratia alba	√	√	√

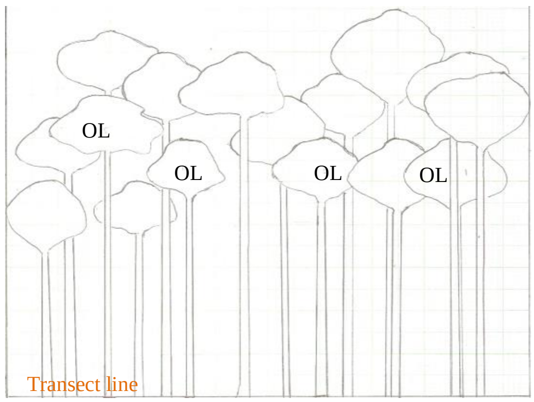
Appendix 8



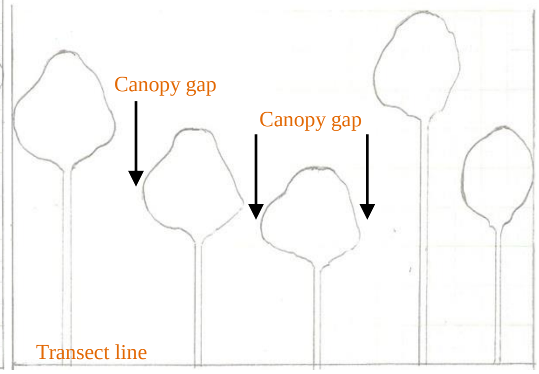
a. SU 1 at Teluk Assam(OL – Tree on transect line)



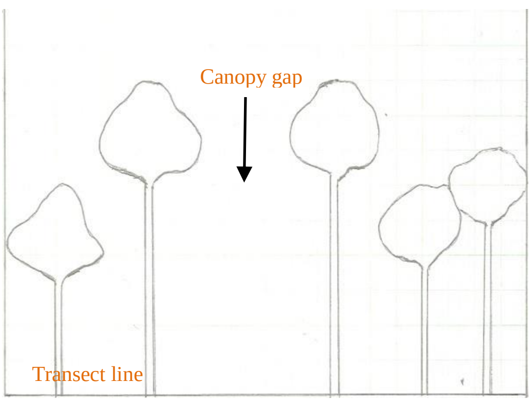
b. SU 2 at Teluk Assam (OL – Tree on transect line)



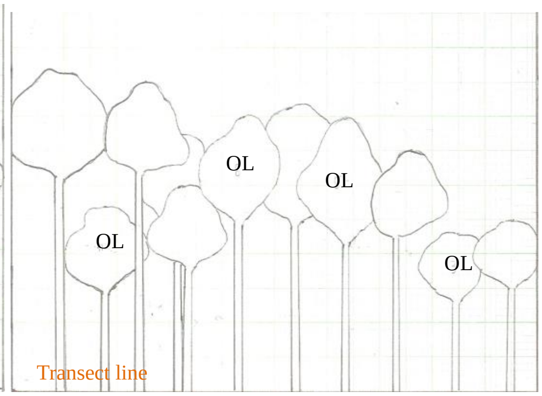
c. SU 3 at Teluk Assam (OL – Tree on transect line)



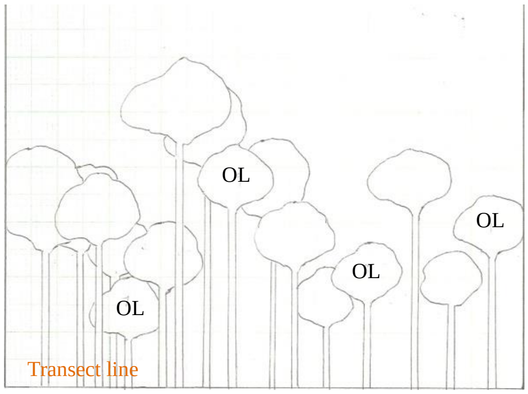
d. SU 4 at Teluk Assam

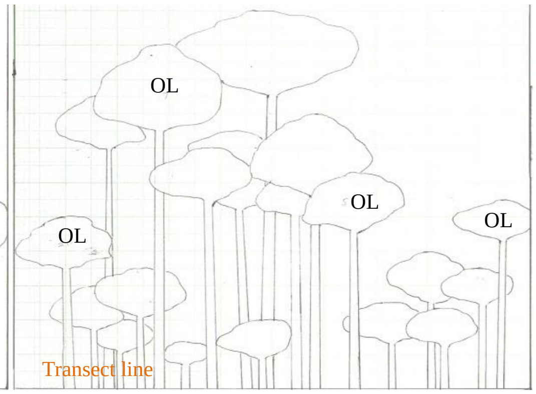


e. SU 5 at Teluk Assam

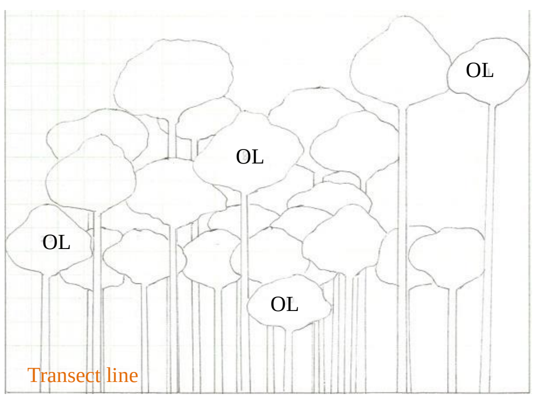


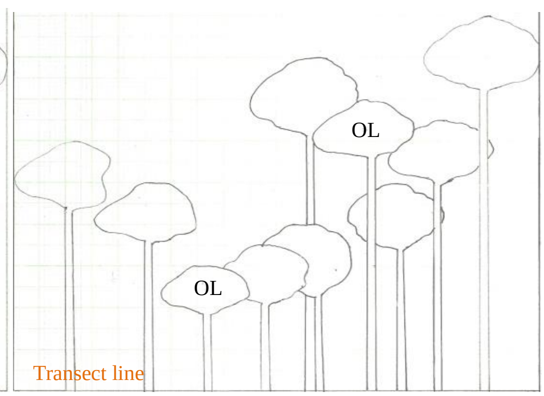
f. SU 6 at Teluk Delima (OL – Tree on transect line)



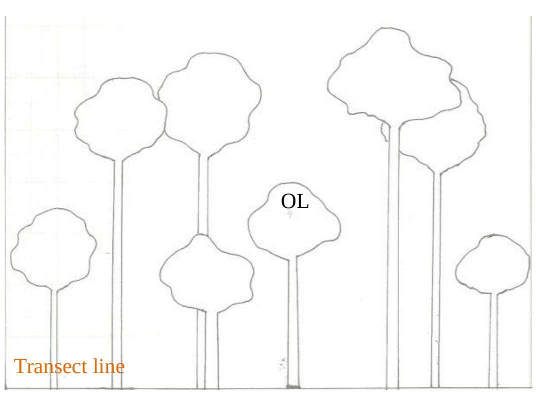


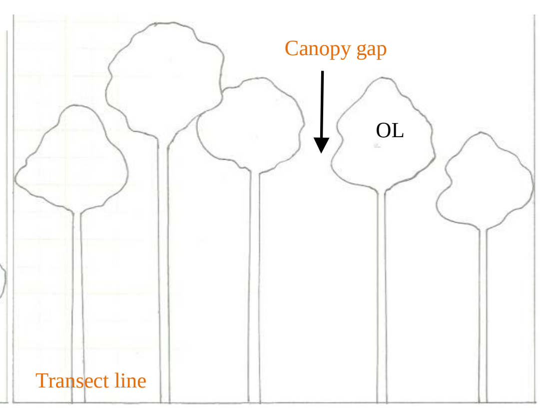
g. SU 7 at Teluk Delima (OL – Tree on transect line) h. SU 8 at Teluk Delima (OL – Tree on transect line)



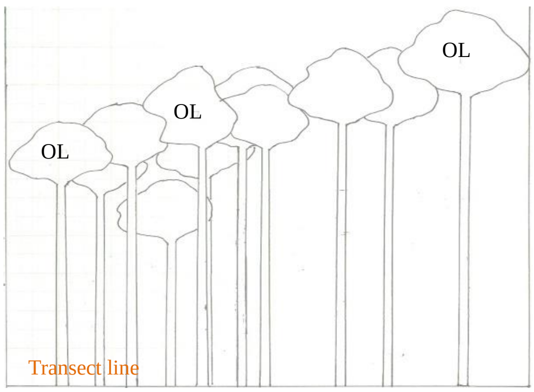


i. SU 9 at Teluk Delima (OL – Tree on transect line)j. SU 10 at Teluk Delima (OL – Tree on transect line)

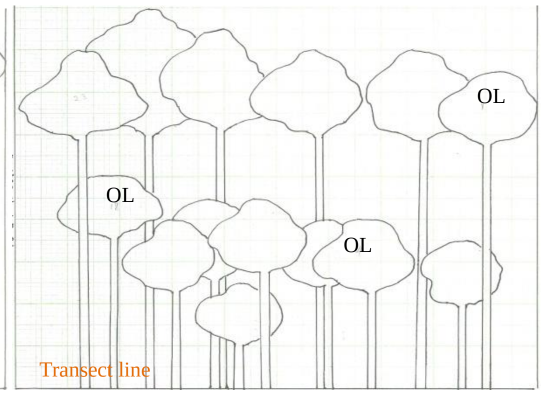




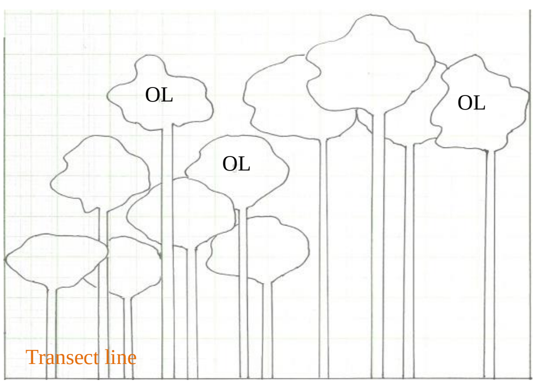
k. SU 11 at Teluk Delima (OL – Tree on transect line)l. SU 12 at Teluk Delima (OL – Tree on transect line)



m. SU 13 at Teluk Delima (OL – Tree on transect line)

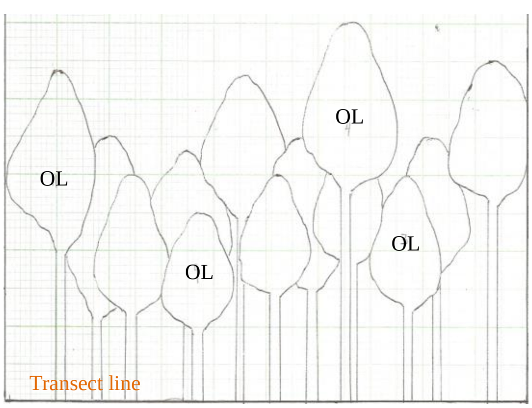


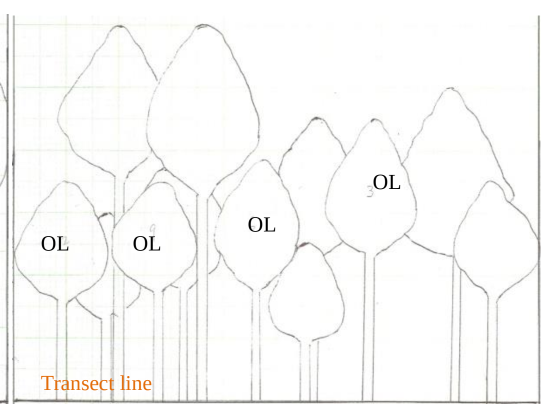
n. SU 14 at Teluk Delima (OL – Tree on transect line)



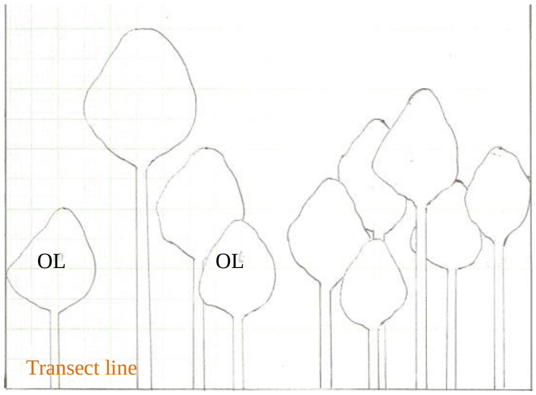
o. SU 15 at Teluk Delima (OL – Tree on transect line)

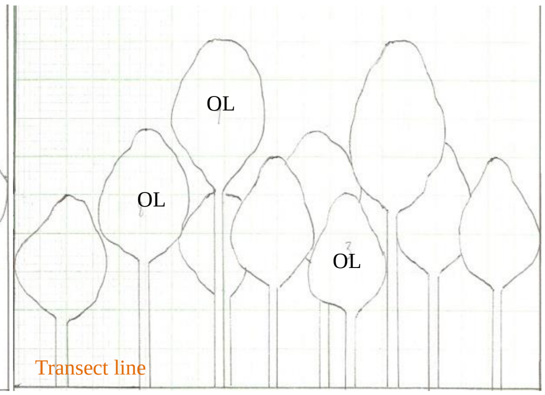
Profile of mangrove stands in SU in Bako National Park



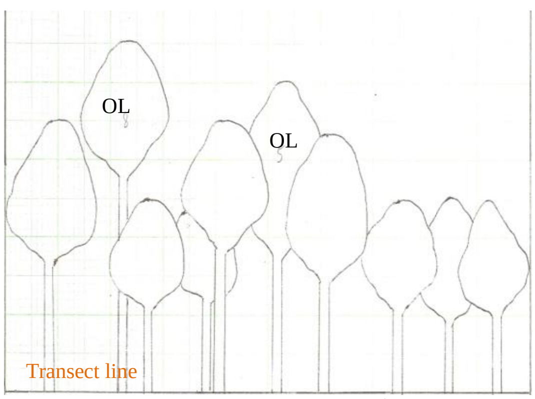


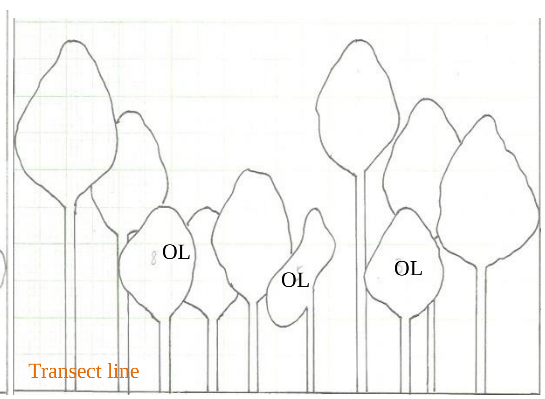
a. SU 1 at site 1 (OL – Tree on transect line)b. SU 2 at site 1 (OL – Tree on transect line)



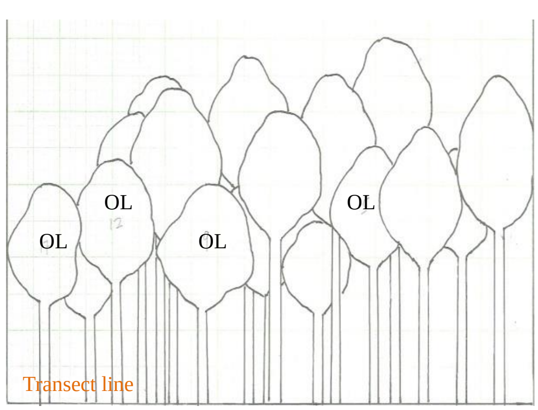


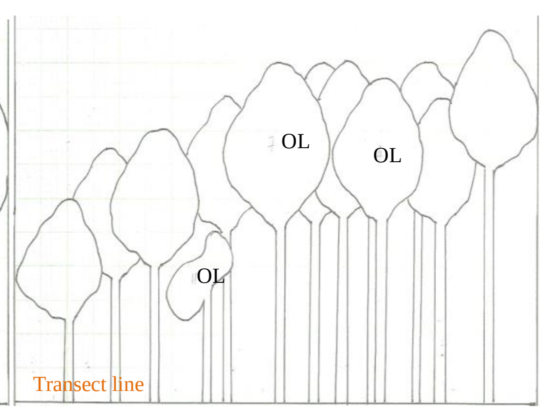
c. SU3 at site 1 (OL – Tree on transect line)d. SU 4 at site 1 (OL – Tree on transect line)



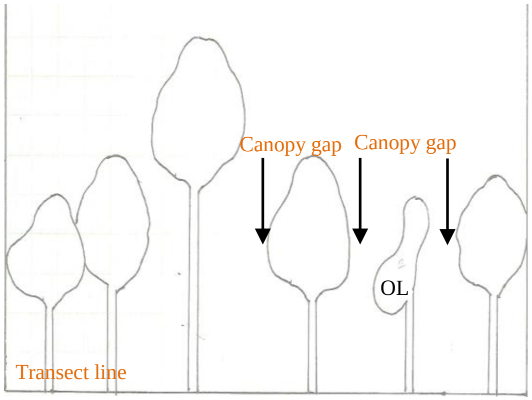


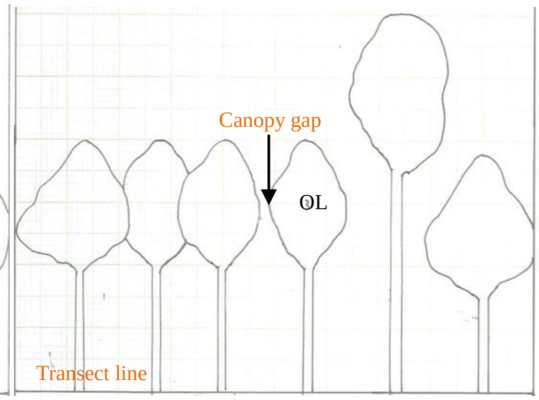
e. SU 5 at site 1 (OL – Tree on transect line)f. SU 6 at site 2 (OL – Tree on transect line)



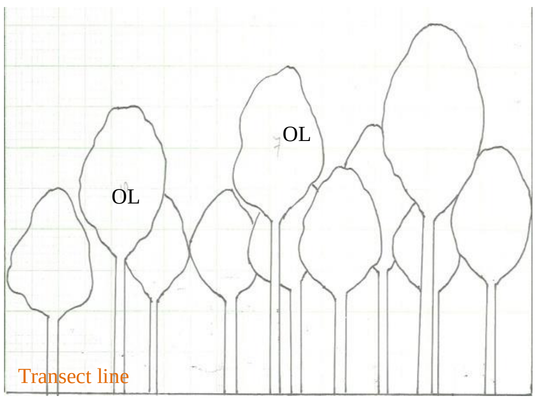


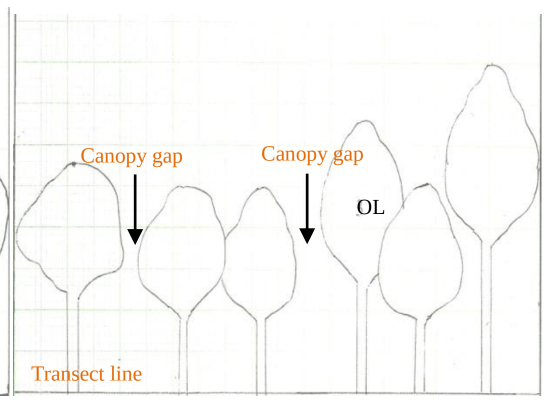
g. SU 7 at site 2 (OL – Tree on transect line)h. SU 8 at site 2 (OL – Tree on transect line)



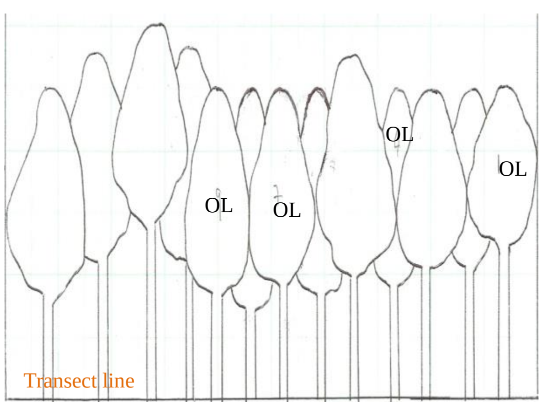


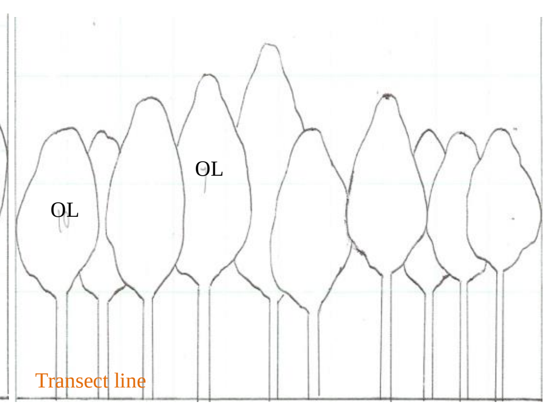
i. SU 9 at site 2 (OL – Tree on transect line)j. SU 10 at site 2 (OL – Tree on transect line)



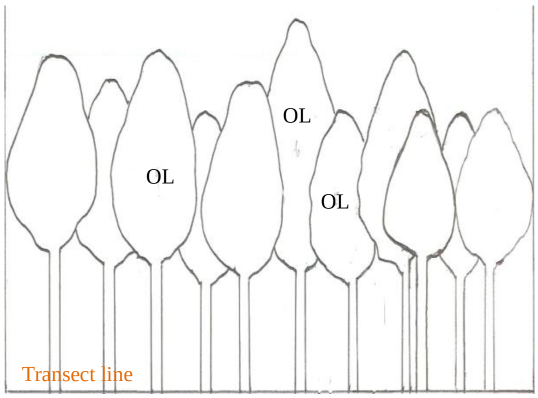


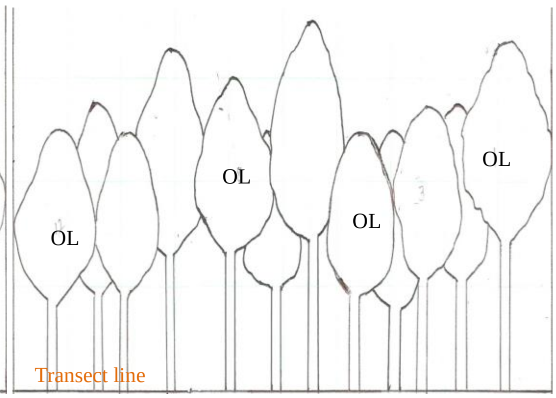
k. SU 11 at site 3 (OL – Tree on transect line)l. SU 12 at site 3 (OL – Tree on transect line)



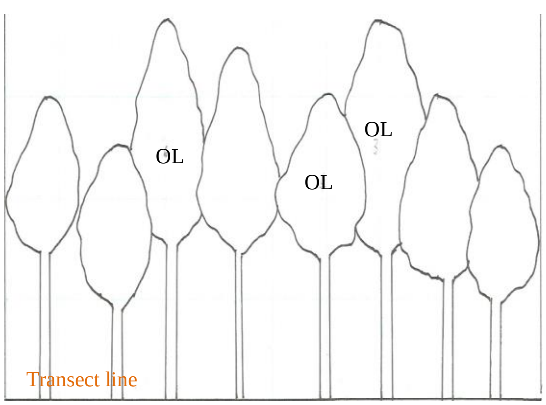


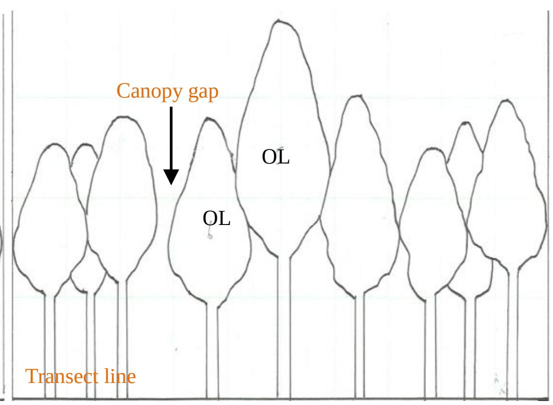
m. SU 13 at site 3 (OL – Tree on transect line)n. SU 14 at site 3 (OL – Tree on transect line)



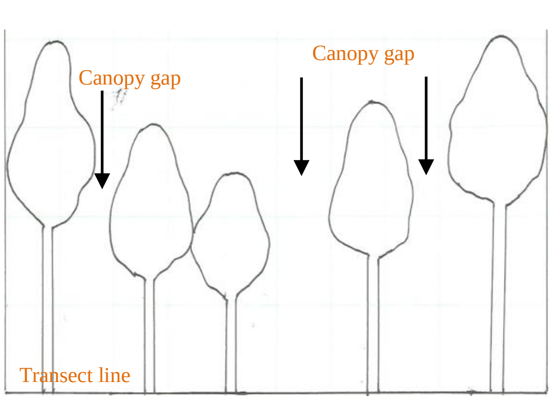


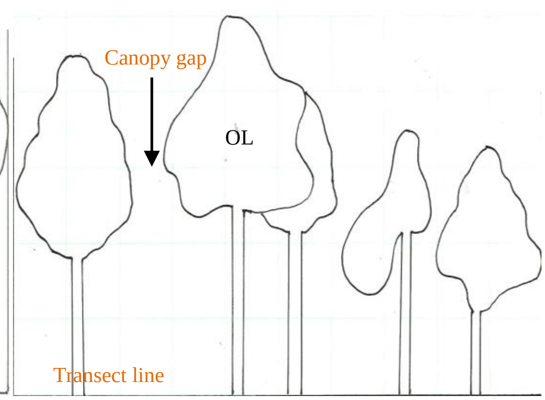
o. SU 15 at site 3 (OL – Tree on transect line)p. SU 16 at site 4 OL – Tree on transect line



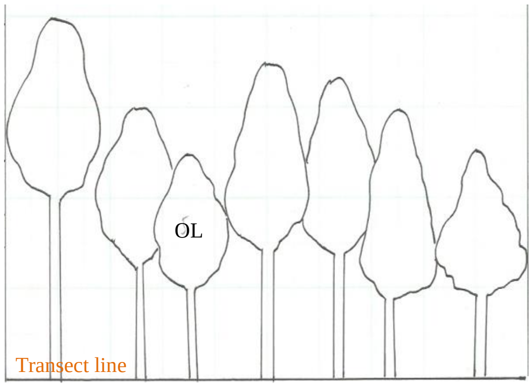


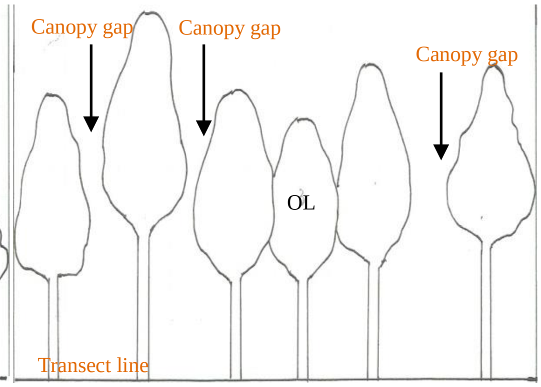
q. SU 17 at site 4 (OL – Tree on transect line)r. SU 18 at site 4 (OL – Tree on transect line)



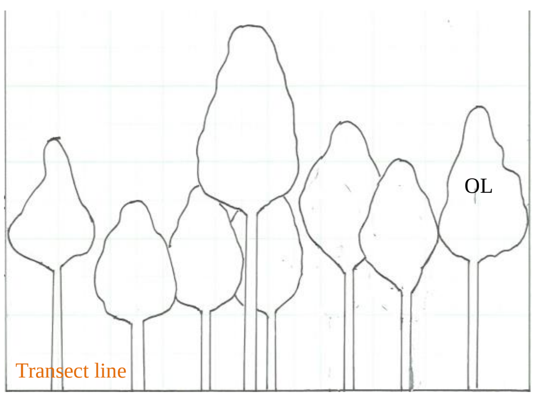


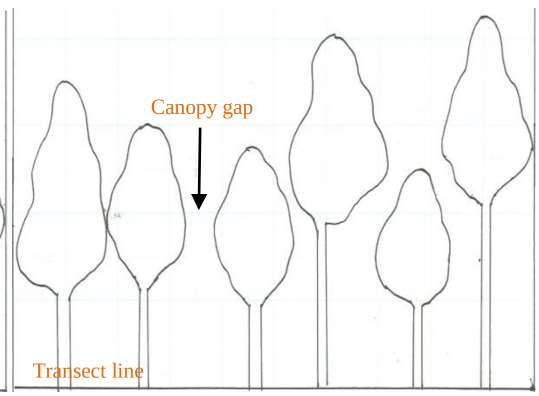
s. SU 19 at site 4 (OL – Tree on transect line)t. SU 20 at site 4 (OL – Tree on transect line)



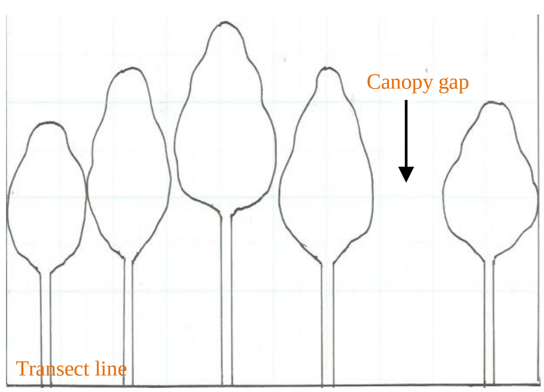


u. SU 21 at site 5 (OL – Tree on transect line)v. SU 22 at site 5 (OL – Tree on transect line)



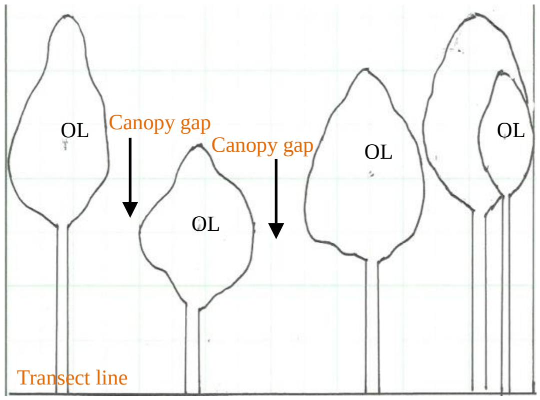


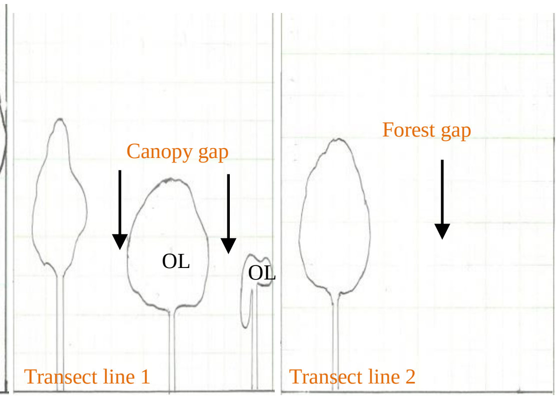
w. SU 23 at site 5 (OL – Tree on transect line)x. SU 24 at site 5



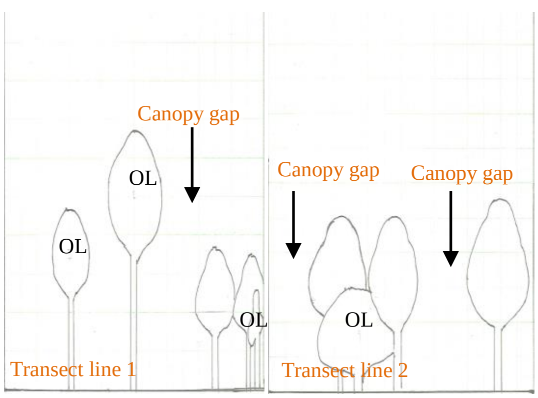
y. SU 25 at site 5

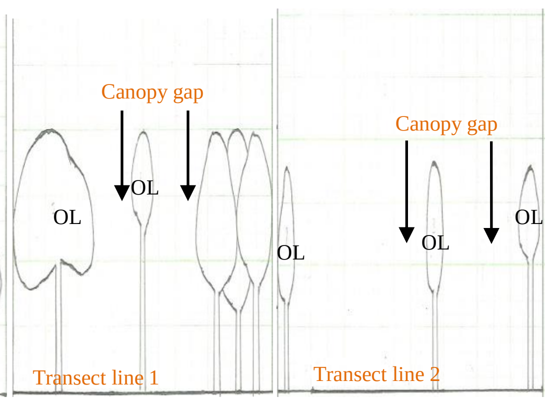
Profile of mangrove stands in SU in Kuching Wetland National Park



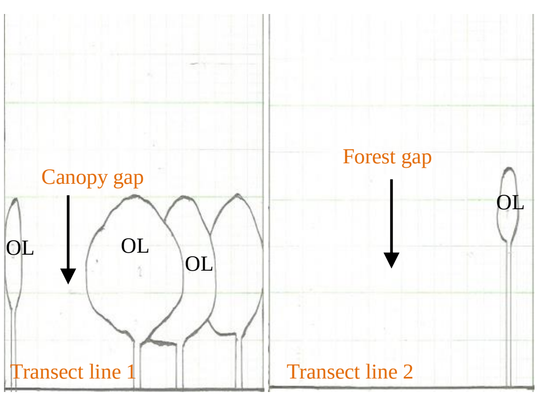


a. SU 1 at site 1 (OL – Tree on transect line)b. SU 2 at site 1 (OL – Tree on transect line)



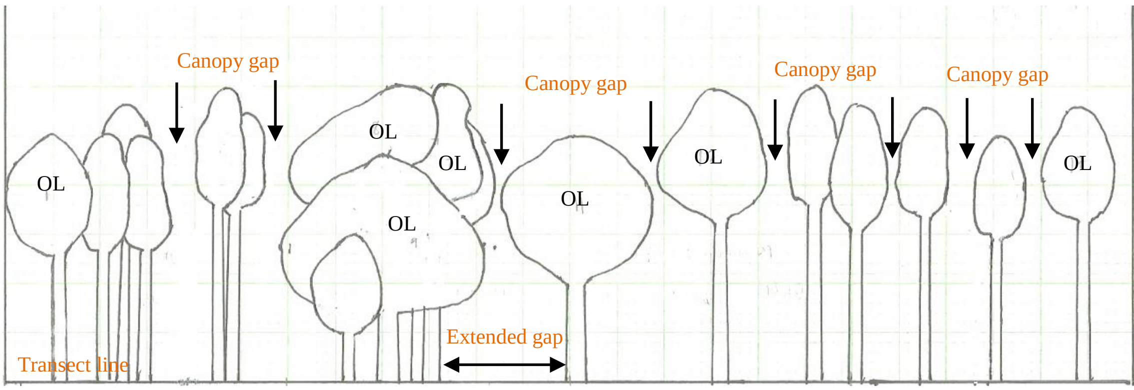


c. SU 3 at site 1 (OL – Tree on transect line)d. SU 4 at site 2 (OL – Tree on transect line)



e. SU 5 at site 2 (OL – Tree on transect line)

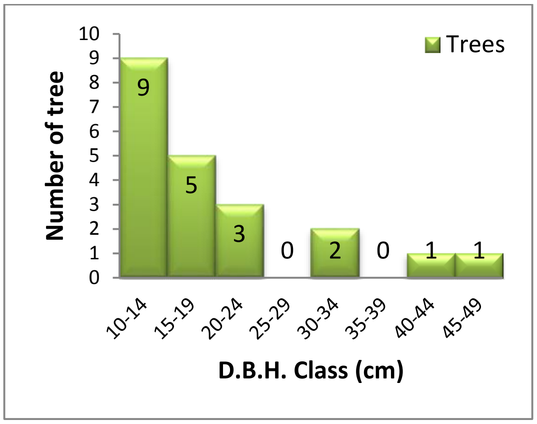
Profile of mangrove stands in Selabat

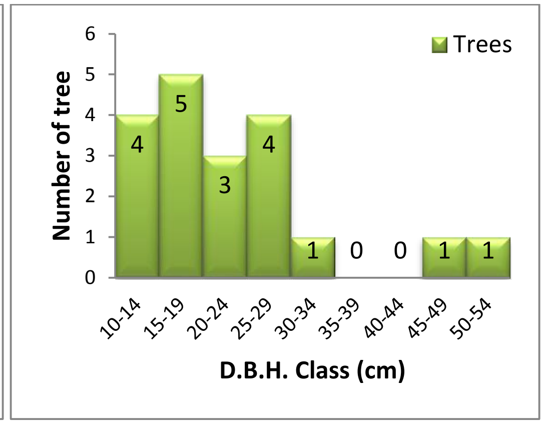


OL – Tree on transect line

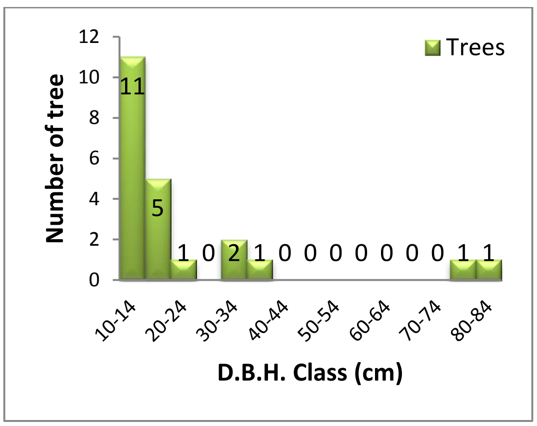
Profile of stands at Bako High School

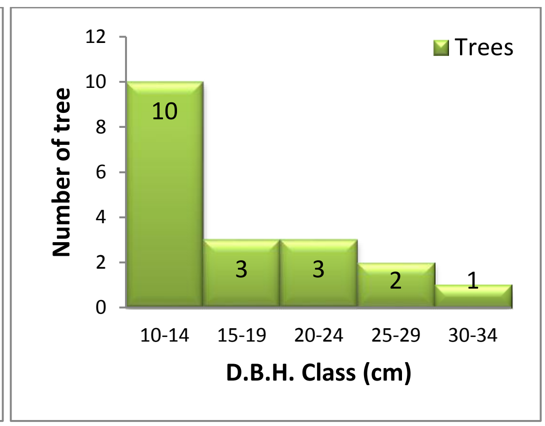
Appendix 9



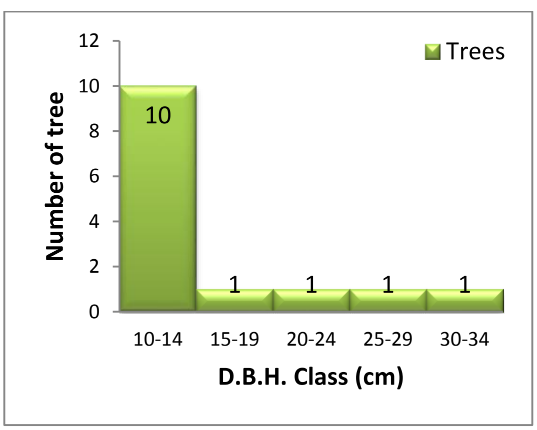


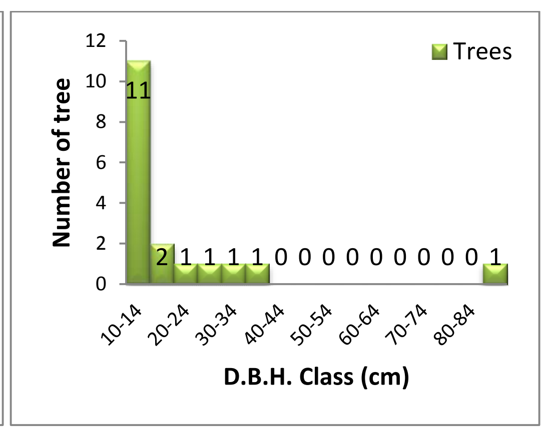
a. SU 1 (linear plot) at site 1 (BA = 37.51 m²ha-¹)b. SU 2 (linear plot) at site 1 (BA = 49.05 m²ha-¹)



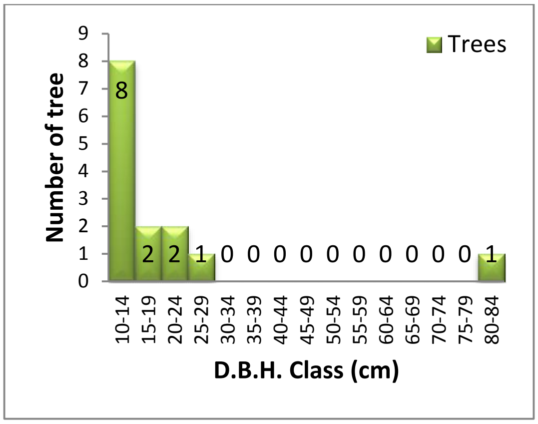


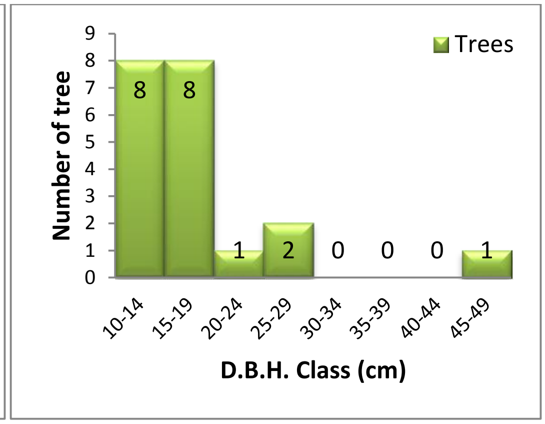
c. SU 3 (linear plot) at site 1 (BA = 78.12 m²ha-¹)d. SU 4 (linear plot) at site 1 (BA = 25.20 m²ha-¹)



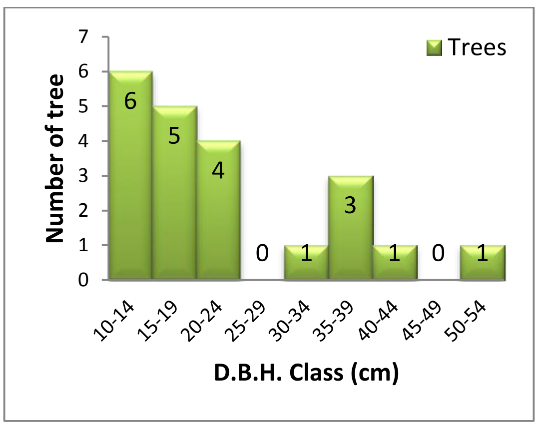


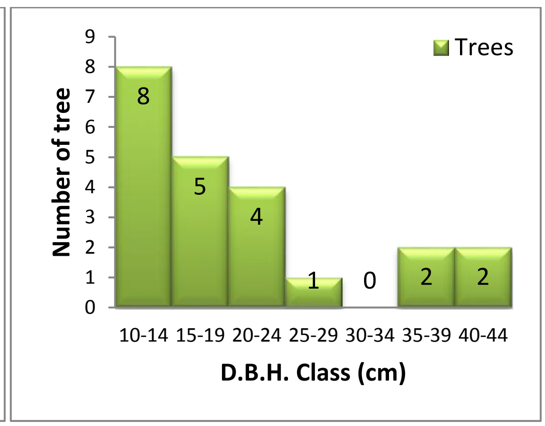
e. SU 5 (linear plot) at site 1 (BA = 16.16 m²ha-¹)f. SU 6 (linear plot) at site 2 (BA = 53.92 m²ha-¹)



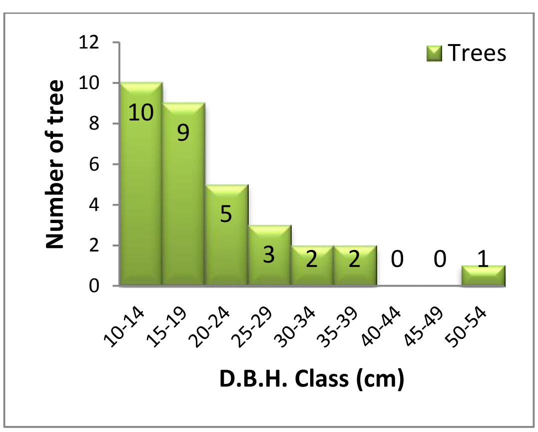


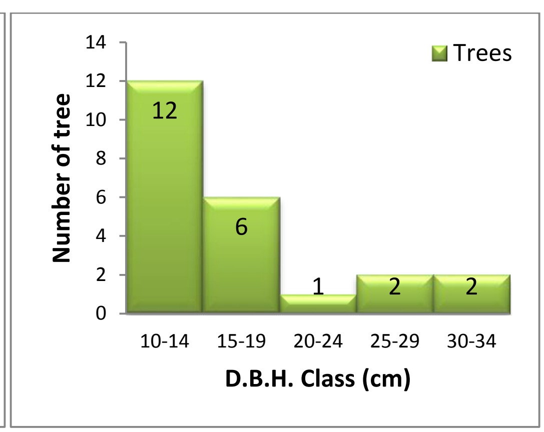
g. SU 7 (linear plot) at site 2 (BA = 38.36 m^2ha^{-1})h. SU 8 (linear plot) at site 2 (BA = 29.67 m^2ha^{-1})



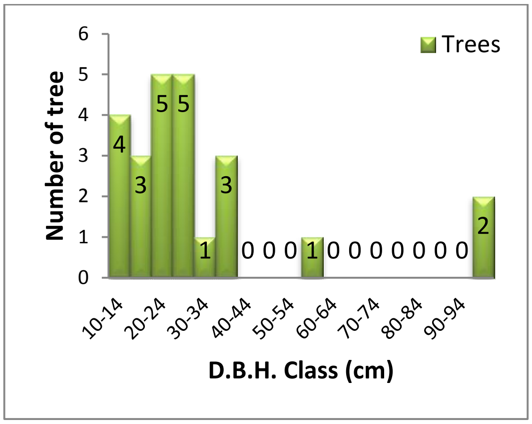


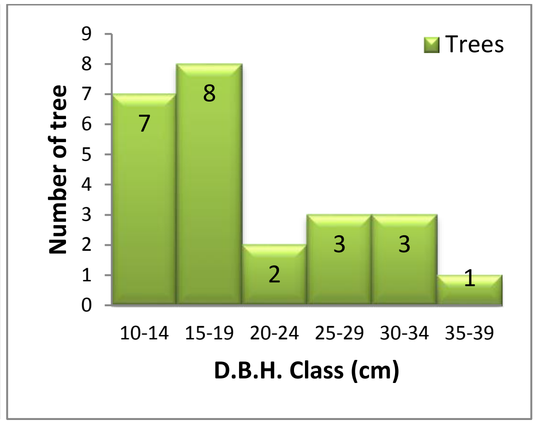
i. SU 9 (linear plot) at site 2 (BA = 56.87 m^2ha^{-1})j. SU 10 (linear plot) at site 2 (BA = 46.47 m^2ha^{-1})



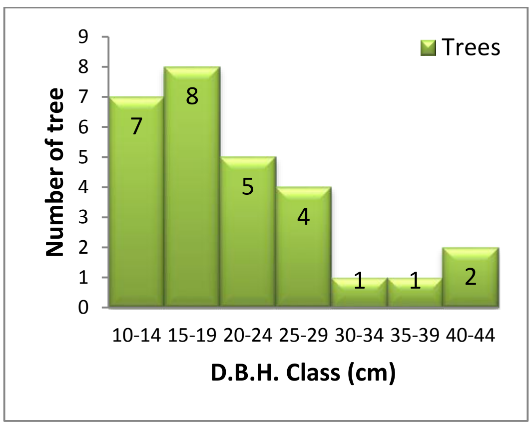


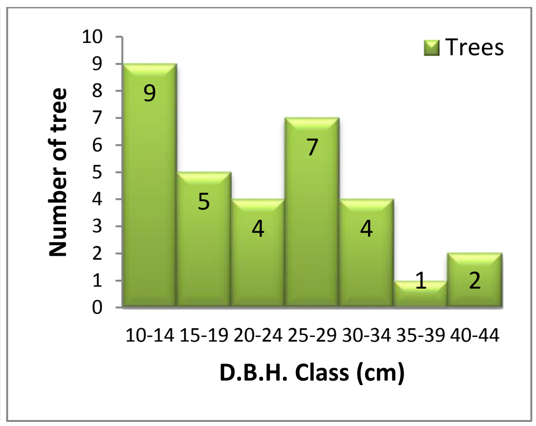
k. SU 11 (linear plot) at site 3 (BA = 62.03 m^2ha^{-1})l. SU 12 (linear plot) at site 3 (BA = 27.84 m^2ha^{-1})



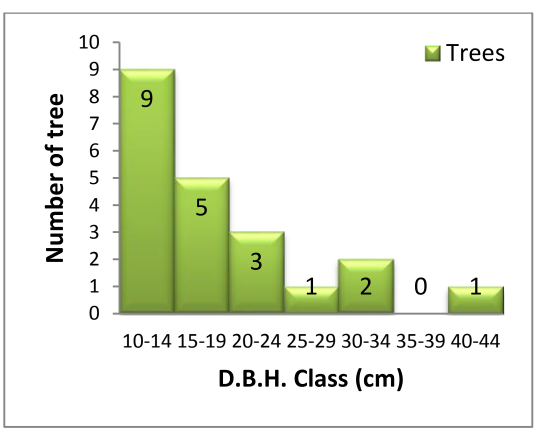


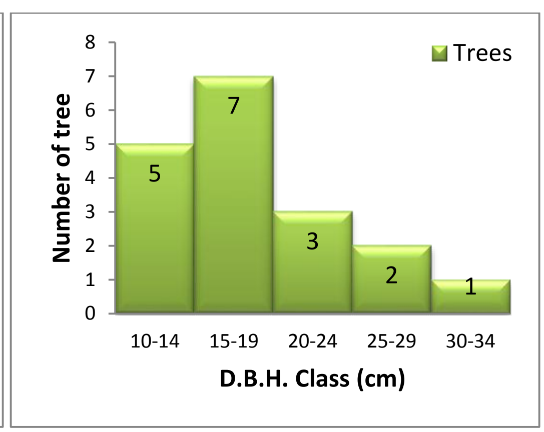
m. SU 13 (linear plot) at site 3 (BA = 99.49 m^2ha^{-1})n. SU 14 (linear plot) at site 3 (BA = 42.17 m^2ha^{-1})



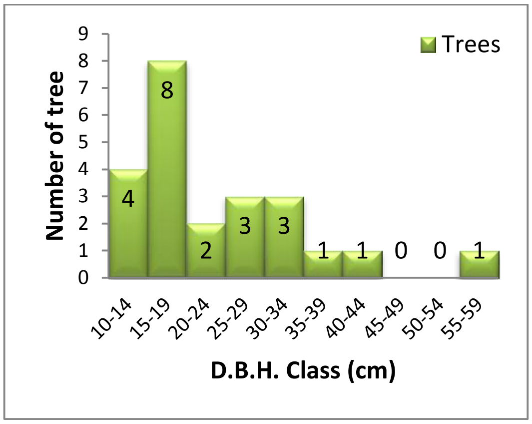


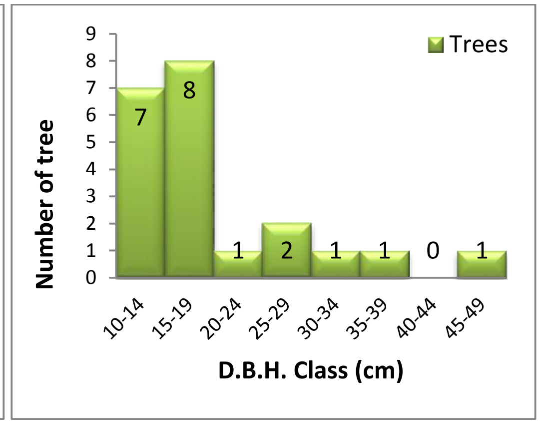
o. SU 15 (linear plot) at site 3 (BA = 55.76 m^2ha^{-1})p. SU 16 (linear plot) at site 4 (BA = 69.80 m^2ha^{-1})





q. SU 17 (linear plot) at site 4 (BA = 32.01 m^2ha^{-1}) r. SU 18 (linear plot) at site 4 (BA = 25.71 m^2ha^{-1})





s. SU 19 (linear plot) at site 4 (BA = 60.27 m²ha-¹)t. SU 20 (linear plot) at site 4 (BA = 38.89 m²ha-¹)

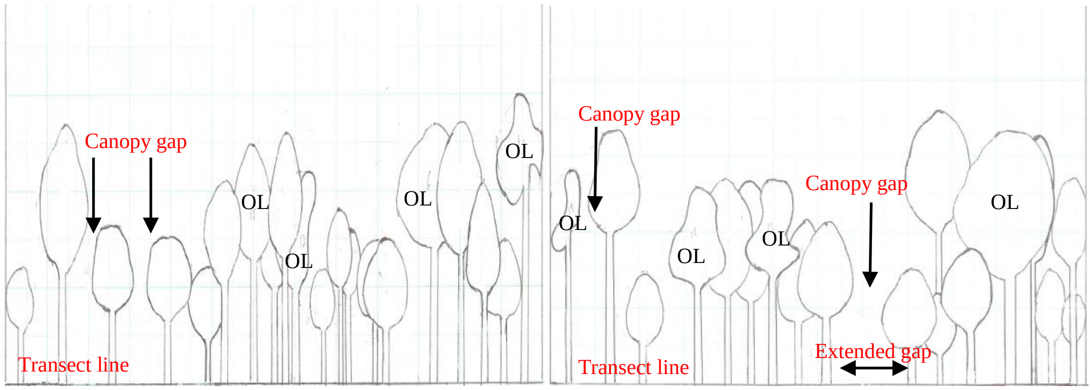
D.B.H. class distribution of trees in swamp forest

Appendix 10

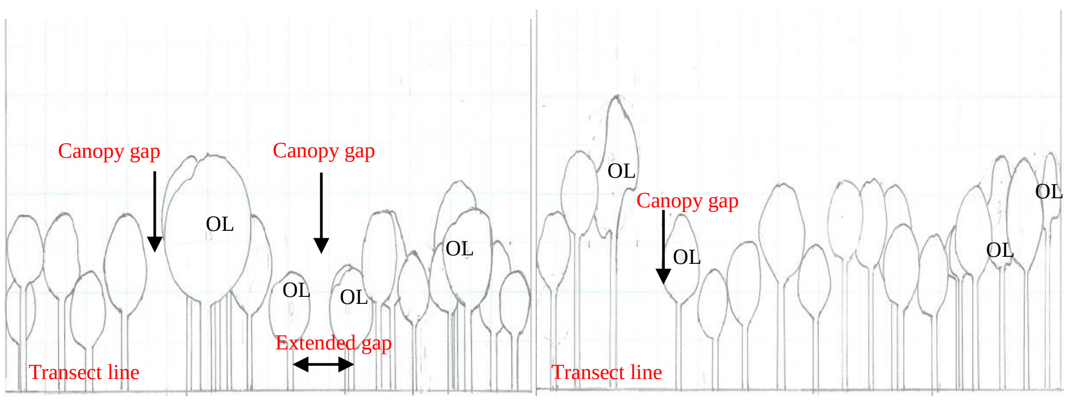
List of species in swamp forest in Maludam National Park

Species names	Source of food plants obtained		
	Literature	This study	Local people
Aglaia sp.			
Baccaurea sp.	√		
Blumeodendron kuzii			
Blumeodendron tokbrai			
Campnosperma sp.			
Combretocarpus rotundatus	√		√
Copaifera palustris			
Dacryodes sp.			
Dactylocladus stenostachys			
Dialium laurinum			
Diospyros evena			
Diospyros sp.	√		
Durio carinatus			√
Elaeocarpus sp.	√		
Ficus annulata	√		
Ganua sp.	√		
Gardenia pterocalyx			
Glochidion sp.			
Gymnacranthera eugeniifolia			
Ilex sp.			
Koompassia malaccensis			
Litsea sp.	√	√	
Lophopetalum sp.			
Macaranga sp.	√		
Myristica lowiana		√	
Neoscortechinia kingii			
Nephelium maingayi			
Parastemon urophyllum	√		
Parishia sp.			
Phoeba opaca			
Polyalthia sp.	√		
Quassia sp.			
Sandoricum emarginatum			
Santiri sp.			
Shorea albida			
Shorea sp.	√		
Syzygium sp.	√	√	√
Vatica mangachapoi			
Xanthophyllum sp.			
Xerospermum acuminatissimum			
Xylopia coriifolia			

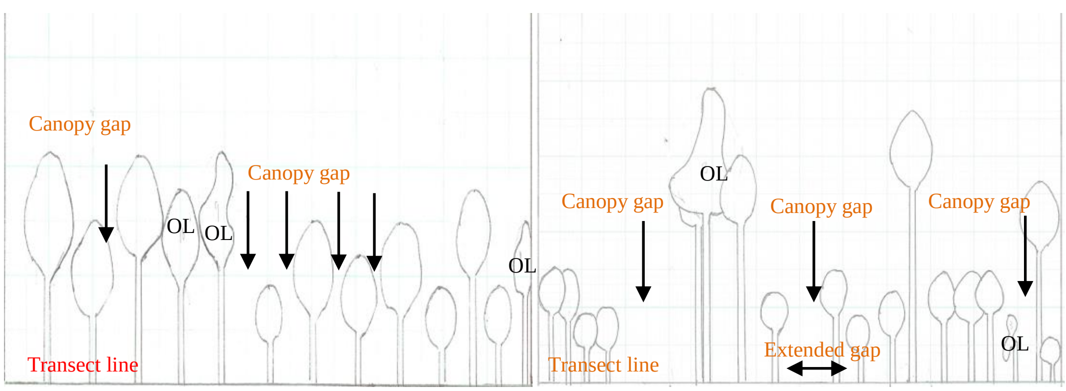
Appendix 11



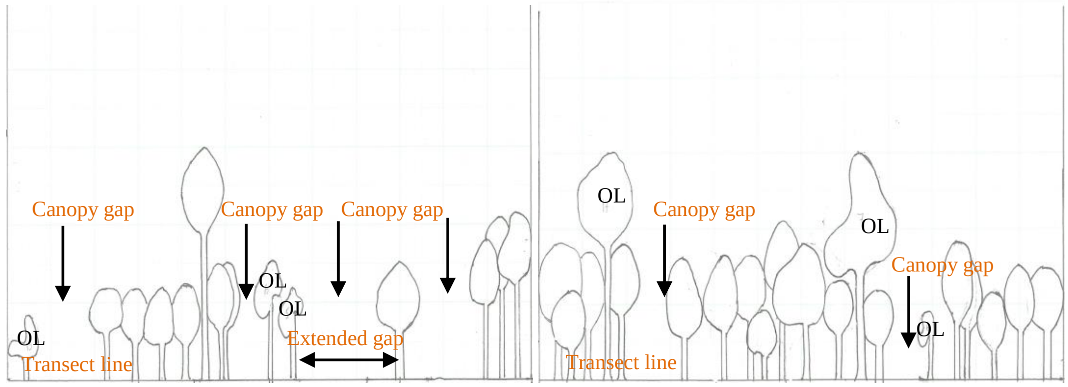
a. SU 1 at site 1 (OL – Tree on transect line)b. SU 2 at site 1 (OL-Tree on transect line)



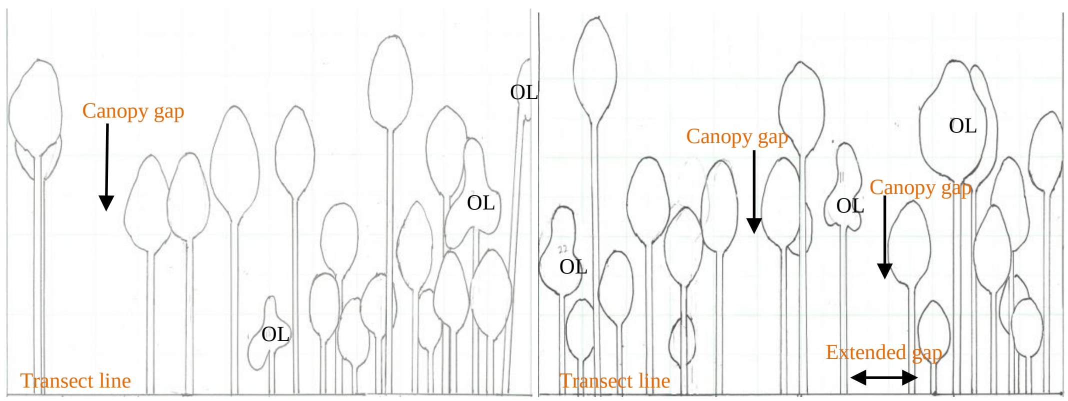
c. SU 3 at site 1 (OL-Tree on transect line)d. SU 4 at site 1 (OL-Tree on transect line)



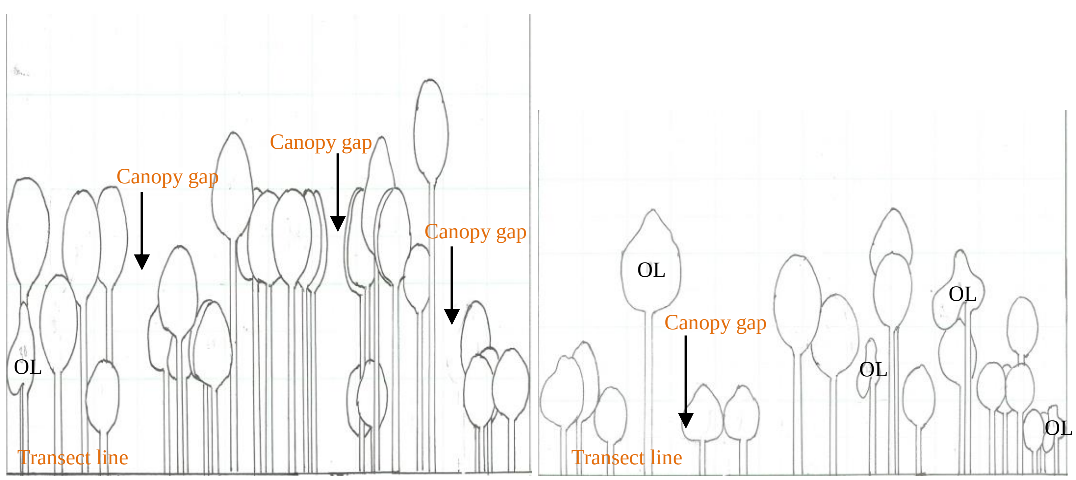
e. SU 5 at site 1 (OL-Tree on transect line)f. SU 6 at site 2 (OL-Tree on transect line)



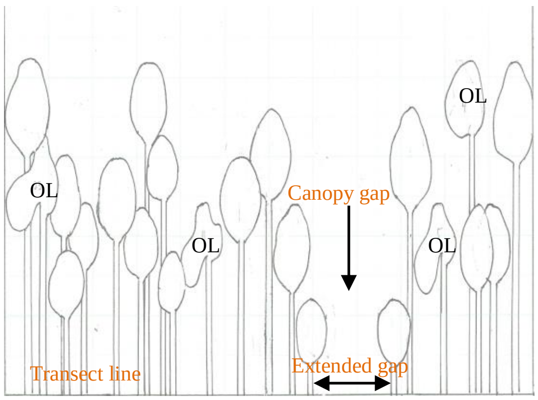
g. SU 7 at site 2 (OL-Tree on transect line)h. SU 8 at site 2 (OL-Tree on transect line)

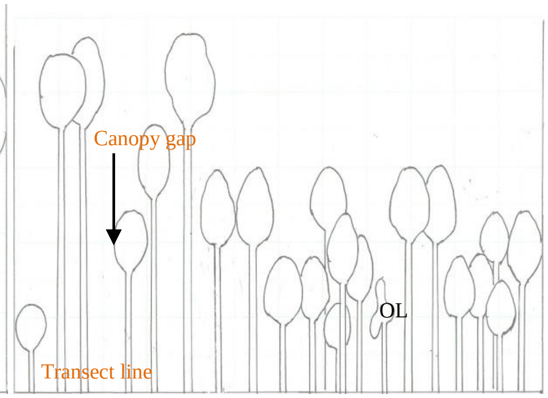


i. SU9 at site 2 (OL-Tree on transect line)j. SU 10 at site 2 (OL-Tree on transect line)

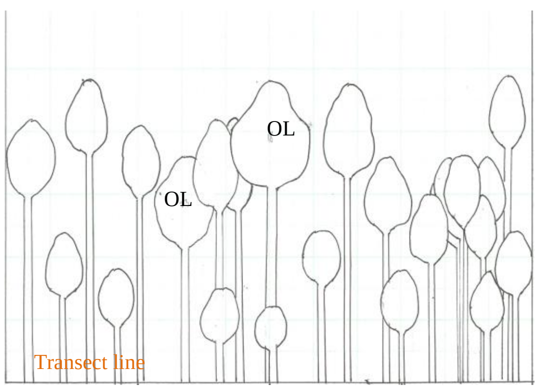


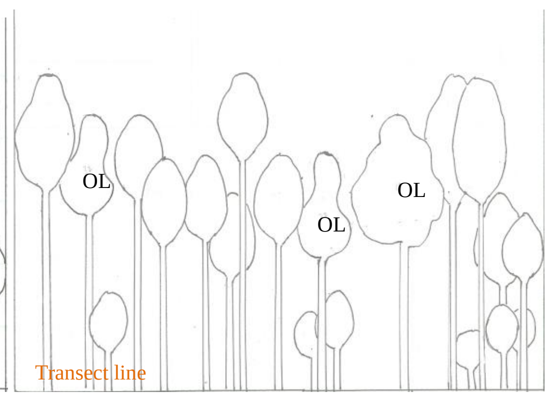
k. SU 11 at site 3 (OL-Tree on transect line)l. SU 12 at site 3 (OL-Tree on transect line)



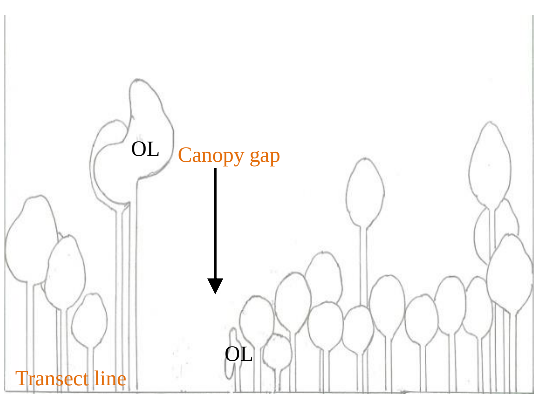


m. SU 13 at site 3 (OL-Tree on transect line)n. SU 14 at site 3 (OL-Tree on transect line)

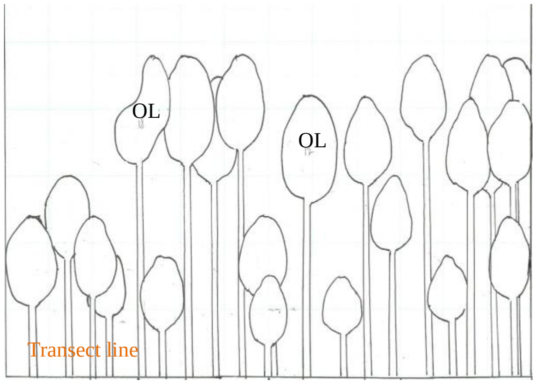


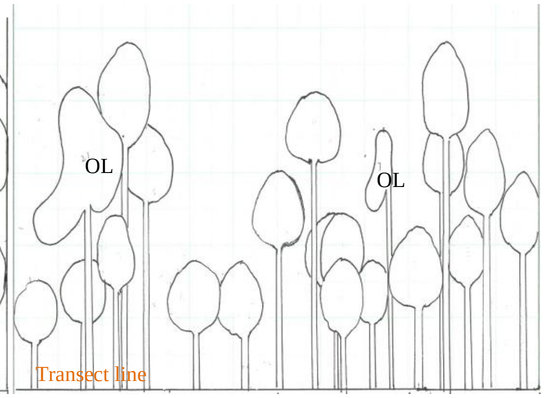


o. SU 15 at site 3 (OL-Tree on transect line)p. SU 16 at site 4 (OL-Tree on transect line)



q. SU 17 at site 4 (OL-Tree on transect line)r. SU 18 at site 4 (OL-Tree on transect line)





s. SU 19 at site 4 (OL-Tree on transect line)t. SU 20 at site 4 (OL-Tree on transect line)

Profile of stands in SU in swamp forest

Appendix 12

Survey Form - Foraging Behaviour

Foraging Behaviour Study site:							Recorded by:				Sheet no:		
Date:				Time:				Weather:				Temperature:	
Category of PM : 1.Adult male/female, 2.Sub-adult male/female, 3.Pregnant/lactating female, 4.Juvenile male/female, 5.Infant 2/1													
Observation time (minute)	Feeding						Travelling	Resting	Other	Sleeping Place	Feeding Place	Food Plant	Remark
	YL	FB	Fl	GF	RF	Etc							
6:30 - 6:35 am													
7:05 - 7:10 am													
7:40 - 7:45 am													
8:15 - 8:20 am													
8:50 - 8:55am													
9:25 - 9:30am													
10:00-10:05am													
10:35-10:40am													
11:10-11:15am													
11:45-11:50am													
12:20-12:25pm													
12:55 - 1:00 pm													
1:30 - 1:35 pm													
2:05 - 2:10 pm													
2:40 - 2:45 pm													
3:15 - 3:20 pm													
3:50 - 3:55 pm													
4:25 - 4:30pm													
5:00 - 5:05pm													
5:35 - 5:40pm													
6:10 - 6:15pm													
6:45 - 6:50pm													

Appendix 13

Food plants eaten by the study group of Proboscis Monkey in Bako National Park

Family	Species name	Common name	YL	FB	Fl	GFr	S	LB	Sh
Anacardiaceae	*Buchanania arborescens*	Otak udang	√				√		√
	Parishia insignis	Upi bung	√						
	Parishia maingayi	Upi paya	√						
Annonaceae		Liana			√				
	Xylopia ferruginea	Ako jangkar	√						
	Xylopia fusca	Ako tembaga	√						√
Arecaceae	*Oncosperma tigillaria*	Nibong			√			√	
Avicenniaceae	*Avicennia alba*	Api-api hitam	√						√
	Avicennia marina	Api-api merah	√						√
Clusiaceae	*Calophyllum inophyllum*	Bintangor laut	√						√
	Calophyllum lanigerum	Bintangor gading	√		√		√		√
	Garcinia bancana	Kandis daun besar	√						√
	Garcinia cuneifolia	Kandis daun kecil/ kandis padang	√						√
	Garcinia penangiana	Kandis kerangas	√						
	Mesua calophylloides	Mergasing	√						√
Combretaceae	*Termanila cattapa*	Ketapang	√			√			√
Dipterocarpaceae	*Cotylelobium burckii*	Resak durian	√						
	Dipterocarpus nudus	Keruing lichin	√						
	Shorea coriacea	Meranti tangkai panjang	√						
	Shorea multiflora	Lun jantan	√						
Euphorbiaceae	*Austrobuxus nitidus*	Ubah banih	√						
Fabaceae	*Peltophorum pterocarpum*	Yellow flame	√						
	Pongamia pinnata	Biansu laut	√						
Lauraceae	*Litsea* sp.	Medang	√						√
Lecythidaceae	*Barringtonia asiatica*	Putat laut	√						
Lythraceae	*Lagerstroemia speciosa*	Bungor raya	√						
Malvaceae	*Hibiscus tilliaceus*	Baru laut	√						
Melastomataceae	*Melastoma malabathricum*	Engkudok	√						

YL – young leaves, FB – flower bud, Fl – Flower, GFr – Green fruit, RFr – Ripe fruit, S – Seed, LB, - Leave base, Sh - shoot

Food plants eaten by the study group of Proboscis Monkey in Bako National Park ......Continued

Family	Species name	Common name	YL	FB	Fl	GFr	S	LB	Sh
Moraceae	*Ficus benjamina*	Ara dunuk	√						√
Myristicaceae	*Myristica lowiana*	Kumpang pendarahan					√		
Myrsinaceae	*Ardisia elliptica*	Merjemah laut	√						
Myrtaceae	*Syzygium adenophylla*	Ubah daun kecil	√				√		√
	Syzygium chloraniha	Ubah kerangas	√						
	Syzygium multibracteolata	Ubah	√						
	Syzygium polyantha	Ubah laut	√						
	Syzygium rejangense	Ubah jambu	√						
	Syzygium spp.	Ubah	√				√		√
	Tristaniopsis microcarpa	Selunsur bersayap	√						
	Tristinopsis whitiana	Selunsur	√						
	Whiteodendron moultonianum	Kawi	√						√
Pandanaceae	*Pandanus odoratissimus*	Pandan						√	
Rhizophoraceae	*Rhizophora apiculata*	Bakau minyak	√						√
	Rhizophora mucronata	Bakau kurap	√						√
Rubiaceae	*Canthium umbelligerum*	Tulang ular					√		
	Aidia sp.	Liana					√		
Sapotaceae	*Palaquium gutta*	Nyatoh rian			√				√
	Palaquium rufolanigerum	Nyatoh sudit					√		
	Planchonella obovata	Nyatoh laut	√						√
Sonneratiaceae	*Sonneratia alba* J. Sm.	Perepat	√			√	√		√
Theaceae	*Adinandra collina*	Legai	√		√				√
	Ploiarium alternifolium	Somah	√						
Tiliaceae	*Pentace rigida*	Baru bukit	√						
Verbenaceae	*Vitex pubescens*	Leban	√	√	√				

YL – young leaves, FB – flower bud, Fl – Flower, GFr – Green fruit, S – Seed, LB, - Leave base, Sh – shoot

Continued..... **Appendix 13**

Food plants eaten by the study group of Proboscis Monkey in Kuching Wetland National Park

Family	Species name	Common name	YL	FB	Fl	GFr	S	LB	Sh
Avicenniaceae	*Avicennia alba*	Api-api hitam	√						√
	Avicennia marina	Api-api merah	√						√
Meliaceae	*Xylocarpus granatum*	Nyireh bunga	√						√
Rhizophoraceae	*Rhizophora apiculata*	Bakau minyak	√						√
	Rhizophora mucronata	Bakau kurap	√						√
Sonneratiaceae	*Sonneratia alba* J. Sm.	Perepat	√			√	√		√

YL – young leaves, FB – flower bud, Fl – Flower, GFr – Green fruit, S – Seed, LB, - Leave base, Sh - shoot

Appendix 14

Survey form for recording trail users' activities on trail and disturbed proboscis monkeys' foraging behaviour

Date :................................. Start:………………………am / pm Finish:……………………. am / pm
Sheet 1
Trail:………………………………………………......… Recorder:
....

Minutes	0	15	30	45	60
Arrive					
Photographing					
Binocular					
Talking					
Silent					
Pointing					
Off-trail					
Walking					
Laughing					
Depart					
Activities: Feeding Resting Travelling Other	Disturbed Proboscis Monkey's activities due to visitors' activities on-trail (Sheet 2) ....Yes ....No ....Yes ....No ....Yes ....No ....Yes ....No Legend: M-Male, Fm-Female, C-Children; F-Feeding, R-Resting, T-Travelling, O-Other				

Survey form for recording trail users' activities on trail and disturbed proboscis monkeys' foraging behaviour ......Continued

Date: Recorder: Weather**:** Sheet 2

Time	Visitor	PM	W	T	Ph	P	L	S	B	O	Remarks
		F									
		R									
		T									
		O									
		F									
		R									
		T									
		O									
		F									
		R									
		T									
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		F									
		R									
		T									
		O									
		F									
		R									
		T									
		O									
Enter Yes – √ or No – X in appropriate boxes											