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Borneo yellow muntjac (*Muntiacus atherodes*)
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BORNEO : an Introduction

At almost 750,000 km², Borneo ranks as the world's third largest island. The political division between three nations—Malaysia, Brunei Darussalam and Indonesia—and their contrasting histories, have generated economic and cultural distinctions in human society in different parts of this huge island. Nonetheless, geography, climate, and plant and animal ecology provide a unifying environment to justify the theme of this issue of the Malayan Nature Journal. In these pages, participants from all three nations have presented a remarkable collection of reports on aspects of the natural history of Borneo, or parts of Borneo. Collectively, these papers illustrate the diverse character and fascinating breadth of the subject, and celebrate the endeavours of the community of people and institutions who participate in studies that add to our collective understanding of the diverse and remarkable natural history of Borneo.

The opening contribution draws attention to the Proboscis monkey, the long-nosed colobine endemic to Borneo, frequenting coastal and riparian forest throughout the island. Equally well-known is Borneo's great ape, the Orangutan, whose threatened status has roused international and national support for the rescue and rehabilitation programme at Lamadau, Central Kalimantan. Also generated in Indonesia, in West Kalimantan, the Mastwatch website continues to link observers throughout Borneo in a programme to monitor the phenomenon of mast-flowering and fruiting of dipterocarps, the magnificent giant trees that dominate the lowland and lower montane forest of Borneo. There follows a study of the utilisation of natural resources by an indigenous community of Muslim faith.

Move on to the giant mammals, Asian elephants, at last proven by skilled zooarchaeological detective work to be present in Borneo in the Late Pleistocene era. An archaic group among invertebrates, the Odonata (dragonflies and damselflies) are well represented in Borneo; presented here is an overall review and a linked, first Borneo-wide checklist. The birds of Borneo are perhaps a group more often drawing naturalists to Borneo; several checklists exist and it is more cogent to include, in these pages, an authoritative review of ornithology, an active pursuit throughout the island.

There are two contributions from Brunei based on phototrap images. The first provides previously unknown evidence of colour variation among the Sundaic Horse-tailed squirrel, while the second puts into circulation the first pictures of living Borneo Yellow muntjac, and original evidence of ecological separation of the two species of barking deer in Borneo. On the island Mantanani Besar a study, initiated by the Sabah Society, has investigated the human/bird relationship, and assessed the likelihood of a productive future for the strange, mound-building megapodes. A short essay on the cultural significance of Clouded leopard precedes a careful, well illustrated account of the living legend of Tigers in East and North Kalimantan. In the same area, human ingenuity has invented a mechanical alternative to the blowpipe, the traditional hunting weapon of interior people of Borneo. The second-last features a study of the declining mud crabs in Kuching mangroves, and this issue closes on a report showcasing prey-handling of a venomous Bornean Keeled Pit Viper.

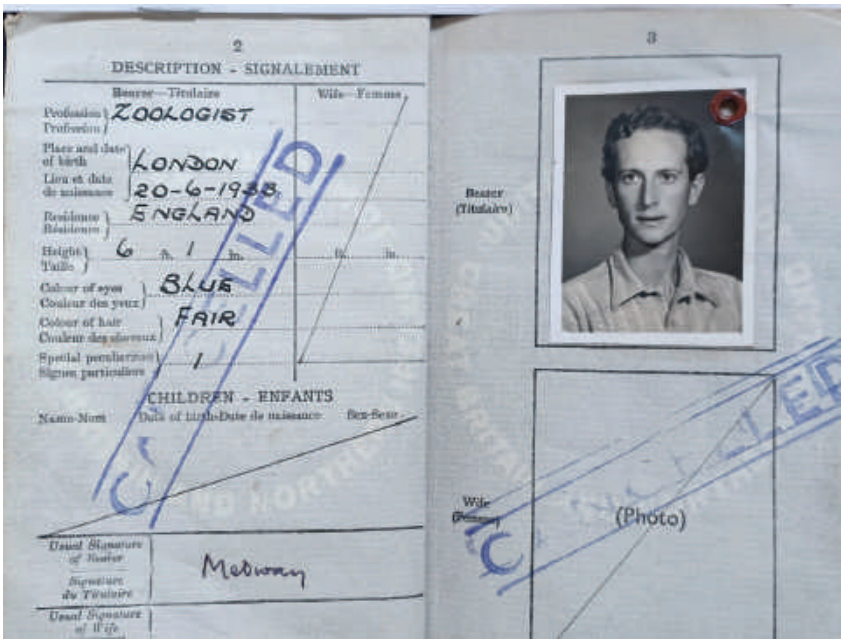
Apologia: lifetime connections with people and places in Borneo

Readers of the Malayan Nature Journal may question my qualification to serve as Guest Editor of this Borneo-themed issue. I hope a few paragraphs can provide satisfactory justification.

Sometimes, in Sarawak, people who half-hear my name, jump to the (wrong) conclusion that I am related to the dynasty of Brooke Rajahs. Dismiss that as the reason why, in March 1956, shortly before graduating at Cambridge, I did not refuse the offer by Tom Harrisson, then Curator of the Sarawak Museum, who offered to give me a job, if I came to Kuching. So, in June 1956, I bought a passage on a cargo steamer of the Blue Funnel Line, from Liverpool to Singapore, where I transhipped to S.S. Rajah Brooke -- and finally arrived at Kuching.

The 'job' was termed 'Technical Assistant to the Curator', and had no fixed duties. The Museum was engaged in a programme of amassing bird skins, funded by the eminent businessman and ornithologist Dato Loke Wan Tho. Young men from rural longhouses were given basic training in skinning and specimen preparation, and sent home with a supply of cartridges, museum labels, cotton wool and preservative. At the Museum, I sorted and identified the resulting skins. This task -- a valuable introduction to the avifauna -- was supplemented by proof-reading B. E. Smythies' new checklist of the birds of Borneo (1957). The text went back and forth (seven times, I remember) between Museum and the Government printer, whose staff were seriously challenged by Latin nomenclature and the arcane rules on the use of italics in zoology. In the same year, I was issued a Sarawak international passport, no. 4553, valid in 'The British Commonwealth and all Foreign Countries'. On this document, I travelled the world for ten years until it expired in February 1967.

Plate 1 - Sarawak International Passport



In 1958, promoted to Archaeological Assistant, I became responsible for the identification of animal remains excavated at Niah caves, and elsewhere in Sarawak and Sabah. As a personal project, the Curator also encouraged me to study the edible-nest swiftlets -- a group of birds with unique adaptations to life in caves. Two years later, my fieldwork on swiftlets became the foundation of a PhD dissertation at the University of Birmingham, U.K. In 1960-1961, a post-doc fellowship with Yayasan Siswa Lokantara (as ahli burung walet) extended my research to Indonesia; Here I found other managed populations of cave swiftlets, and met other scientists prepared to share their experience in the taxonomy and behaviour of these fascinating birds.

In 1961, appointed to the Zoology Department at the University of Malaya, I was well placed to resume research on the animal remains excavated in Malaysian caves, notably at Niah, Sarawak. Discoveries included the foot bones of Malayan tapir, a large mammal now extinct in Borneo, but I failed to find evidence of the past presence of elephant in any Late Pleistocene context.

Most identifiable animal remains in these cave sites consisted of teeth and bones of mammals, encouraging me to study extant Borneo species. In 1965, a grant from U.S. sources funded a round-the-world air ticket. Starting at the B.P. Bishop Museum, Honolulu, and progressing across mainland USA from San Francisco, via Chicago and Washington, D.C., to the Peabody Museum, Yale, and then to museums in London, Paris and Frankfurt, and finally at the India Museum, Calcutta, I managed to see all historic mammal collections from Borneo. During this circumglobal tour, I discovered two undescribed species of small mammal—not in the upland localities they inhabit, but in the museum cabinets where they lay, overlooked: the Grey-bellied pencil-tailed tree-mouse, in the U.S. National Museum, Washington. D.C., USA, and the Black shrew, in the Museum of Comparative Zoology, Cambridge, Mass., USA. The resulting annotated checklist of mammals of Borneo was published by the Malaysian Branch of the Royal Asiatic Society, first in 1965 and, later, as a revised edition, in 1977.

In the 1990s, invited by the Director of Forests and Wildlife, Sarawak, to review the edible birds'-nest industry. I looked for a student-assistant to cooperate in the research. Luckily, Lim Chan Koon, a graduate student at Universiti Malaysia Sarawak (Unimas) was willing to transfer to the topic, He was awarded a Government scholarship to the University of Kent, U.K., and I became external supervisor for his Ph.D. I remembered my 1957 visit to Salai Cave, in the Middle Baram above Long Laput, site of an accessible colony of White-nest swiftlets. We approached YB Kebing Wan, head of the family of hereditary owners of the cave rights, and were pleased by his generous offer to provide facilities for a year's research on site, alongside his relative Usong Wan, as cave manager. This unprecedented opportunity for a dedicated and assiduous student, and for shared learning by myself as supervisor, resulted in a successful graduation by Dr Lim..

In 2001, a grant from Flora and Fauna International helped Dr Lim and myself, with friends from the community of Sarawak birds'-nest cave owners, including George Nawan, to undertake an investigation of birds'-nest operators and island sites in North Kalimantan, and the extensive complex of caves occupied by Black-nest swiftlets in the upper Kayan river, East Kalimantan, managed by a local cooperative. In 2002, our experiences were recounted in a jointly authored book: *Swiftlets of Borneo: builders of edible nests*, produced in a lavishly illustrated edition by Natural History Publications (Borneo) and reissued with revisions in 2014.

In 2009, I was appointed a member of Yayasan Ulin, an Indonesian foundation dedicated to conservation of natural habitat and wildlife in areas unprotected by legislation. I traversed the southern breadth of Borneo by mixed transport modes from Pontianak to Pangkalan Bun, West Kalimantan, across Central Kalimantan, to Banjarmasin and Martapura, South Kalimantan, and later, from Balikpapan to Samarinda and Tenggarong, East Kalimantan, and— later still — from Bandarbaru on the great Mahakam river, by speed boat up the tributary, Sg Belayan, to the oil palm plantations operated by REA Kaltim. The director and staff of REAKon, the conservation arm of this British-owned company, provided valuable insights of the potential for good environmental management on a large commercial plantation.

In 2014, I was invited to participate in the Heart of Borneo initiative, as operated in Brunei Darussalam under Royal patronage and ministerial support. Recipient of a

Merdeka Award in the same year, among other projects, I was able to fund a Sabah graduate of the University of Malaya, for his M Sc research into the Philippine megapodes of the Mantanani archipelago, Kota Belud District, Sabah. In the following years, until the Covid-19 Pandemic closed international travel, I have made at least one visit to a destination in Borneo, and thereby renewed or extended my personal contacts among colleagues who share enthusiasm for all aspects of natural history.

Through the Pandemic years 2020 and 2021, and into 2022, contact has been limited to digital exchanges. As Guest Editor of this Borneo-themed issue of the Malayan Nature Journal, I am supremely grateful to all contributors -- and especially those whom I invited to submit their own stories and discoveries. The subject matter is unlimited. The combination of submissions in this issue indicates the wealth and variety of topics available for research. The published articles demonstrate, emphatically, the assiduity and scrupulous ardour of the diverse community of people whose lives and careers have led them into these fields of research. There is still much more to be discovered. I sincerely hope that this themed issue of MNJ will stimulate further research into the diverse aspects of the natural history of Borneo.

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The distribution, abundance, and community perception of Proboscis Monkey (*Nasalis larvatus*) in Limbang Mangrove National Park, Sarawak

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Abstract : The Proboscis Monkey is endemic to Borneo, where the species is widely distributed in mangroves and estuarine habitat. Sensitive to disturbance, and with a declining population listed by IUCN as 'Endangered', protective legislation is generally in place. Treated as an 'iconic' species for tourism in Sarawak, several mangrove areas have been protected for conservation of the species. Limbang Mangrove National Park is one such place but, with an estimated population of 44 individuals in 2019, had become a critical site. A new survey of 11 boat trips covering 223.59 km of mangrove riverbank in Limbang Mangrove National Park and adjoining estuaries recorded 236 individuals in 34 groups. The estimated population density was 1.03-1.78 individuals/km², and 0.15-0.25 groups/km². Proboscis Monkeys were evenly distributed within the National Park boundaries, but concentrated at the centre of the Park. A questionnaire survey of local communities found that more than 50% of respondents supported conservation of this species. Based on the Boosted Regression Tree analysis, locality and income of the respondents were the most influential factors that influenced their perception towards the conservation of Proboscis Monkey in Limbang Mangrove National Park. We conclude that conservation and sustainable ecotourism activities regarding Proboscis Monkeys in Limbang Mangrove National Park should give priority to carfeful planning, taking into consideration the long-term existence of this totally protected species.

Keywords: Proboscis Monkey, population size, distribution, questionnaire survey

INTRODUCTION

The Proboscis Monkey (Colobinae*, Nasalis larvatus*) is endemic to Borneo, and widely distributed in mangroves and estuarine habitats around the coast (Phillipps and Phillipps 2016). Local names include *Orang Belanda, Rasong*, and, most frequently, *Bekantan* or *Bekatan* (Aziz 2019; Khan *et al*. 2021). The species is characterised by the long, protruding nose of adult males (Bennett and Gombek 1993); juveniles and females have a shorter, snub nose. Proboscis Monkeys habitually form 'harem' groups, comprising of several females, infants, juvaniles and dominated by one adult male (Phillipps and Phillipps 2016). In Sarawak, this monkey has become a tourist icon, as a protected, endemic species.

The Proboscis Monkey has an enormous stomach comprising several compartments, allowing for digestion of cellulose, the main component of leaves (the primary diet of the species) (Bouchop and Martucci 1968; Hladik 1977; Bauchop 1978; Bennett and Gombek 1993). The Proboscis Monkey also supplements its diet with fruits, seeds, and shoots from mangrove plants (Yeager 1989). This species is also the only primate that performs remastication and regurgitation of its food (Matsuda *et al.* 2011).

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Proboscis Monkeys are known to be very sensitive to anthropogenic activities (Wardatuttthoyyibah *et al.* 2019). Proboscis Monkeys have been reported to avoid clear-felled tidal forests and areas around human settlements (Salter *et al.* 1985). In 2000, the conservation status of Proboscis Monkey was elevated from 'Vulnerable' to 'Endangered' under the International Union for Conservation of Nature (IUCN) Red List of Threatened Species, as its population faced a severe decline of 50% during the past 40 years (Meijaard *et al*. 2021). Significant threats to Proboscis Monkey's population include hunting, illegal logging and land conversion (Meijaard and Nijman, 2000).

This endangered species is protected by local laws throughout its distribution. Under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Proboscis Monkey is listed in Appendix I. In Sarawak, Proboscis Monkey is listed as 'Totally Protected' by the Wild Life Protection Ordinance 1998. It is illegal to hunt, capture, kill, sell, import, or export, or possess any part of the species without any written permission from the Wildlife Controller. Anyone found guilty of such offences can be fined RM 30,000 and two-years imprisonment , as stated in section 29(1)(b) of the Sarawak Wild Life Protection Ordinance 1998.

In Sarawak, the first survey of Proboscis Monkeys was conducted by Salter and MacKenzie (1985), who estimated the population to be less than 2,000 individuals. In a repeat survey by Bennett *et al.* (1987), the population was estimated to be less than 1,000 individuals, while the most recent survey by Laman and Aziz (2019) found that the population of Proboscis Monkeys in Sarawak was less than 838 individuals.

Limbang Mangrove National Park is one of several localities in Sarawak known for many years to harbour populations of Proboscis Monkey (Salter and MacKenzie 1985). Laman and Aziz (2019) estimated the current population in Limbang Mangrove National Park to be approximately 44 individuals. Limbang Mangrove National Park has now become a critical habitat for this endemic species. Provided ecotourism initiatives are sustainable, and in line with conservation efforts, the protection of this 'umbrella' species will also indirectly safeguard other vulnerable species found here. Hence, ensuring Proboscis Monkey's long-term persistence is of the highest priority, and monitoring its population is important to advise future adaptive management and conservation actions. Thus, one goal of this study was to verify the present population size and the distribution of Proboscis Monkeys in Limbang Mangrove National Park. An additional objective was to understand the perceptions and awareness among local people towards the conservation of Proboscis Monkey in Limbang Mangrove National Park.

METHODOLOGY

Population Density

A survey of Proboscis Monkeys was conducted within Limbang Mangrove National Park and the nearby tributaries outside national park boundaries. The surveys covered Sungai Limbang, around Pulau Limpaku Pinang, Sungai Rangau Damit, Sungai Buntarang, Sungai Matayong, Sungai Sentabak towards Kampung Patiambun and several tributaries near Sungai Sabukang until the southern edge of the park boundaries, Sungai Pelita (Figure 1).

The boat survey technique follows the methodologies described by Bennett (1987), also used by Bennett and Sebastian (1988), Rajanathan and Bennett (1990), Boonratana (1993), Bernard (1997), Goossens *et al.* (2003), Tuen and Pandong (2007), Aziz and Laman (2018) Laman and Aziz (2019) and Khan *et al.* (2021). The survey was conducted along the riverbank in two sessions within a day; morning and evening sessions that coincide with the peak activities of the Proboscis Monkeys, in order to increase the detection probability. In the morning session, the survey began at sunrise (around 6.30 a.m.) and was completed 90 minutes later. The evening survey started 75–90 minutes before sunset (around 6.30 p.m.). These two timeframes are the best time to conduct Proboscis Monkey surveys as they overlap the species' sleeping and feeding patterns at the riverbank (Payne and Francis 2007; Phillipps and Phillipps 2016).

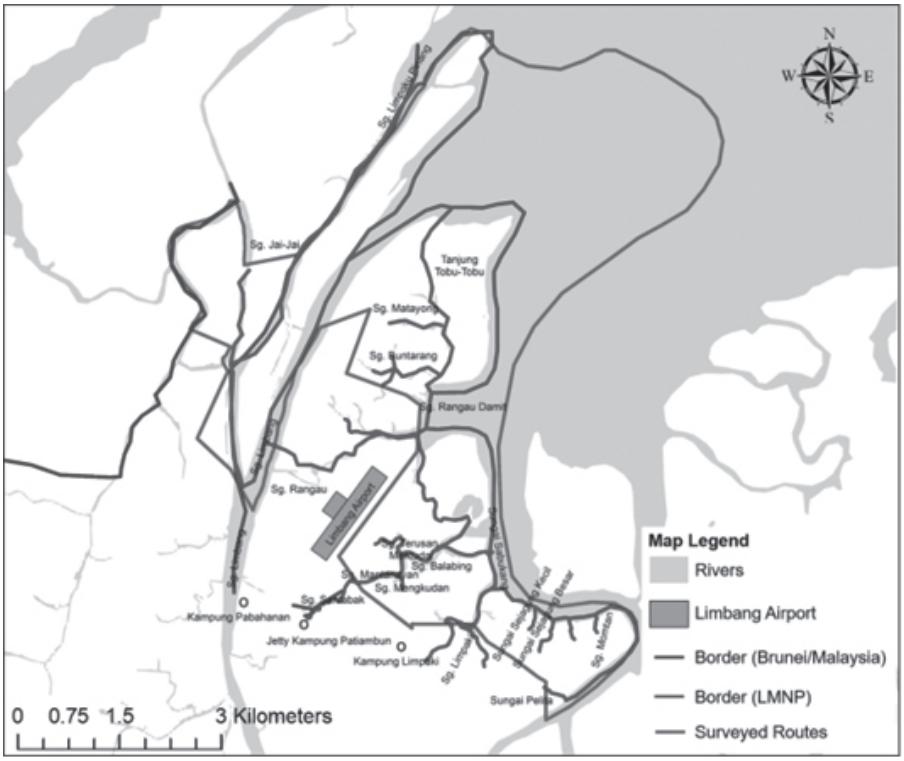

Figure 1: Map of survey routes of Proboscis Monkey in Limbang Mangrove National Park.

Bushnell™ (16 x 50) binoculars were used to observe the monkeys by the riverbanks. When individuals or a group of Proboscis Monkeys was sighted, the boat engine was switched off, and paddles used to move slowly towards the location, until reaching the species' maximum alert distance (usually 50 m) to avoid scaring the monkeys. Group size, location and the tree species occupied by the Proboscis Monkeys were recorded. The starting and ending point coordinates were also recorded during each survey session using Geographic Positioning System (Garmin™ GPS 64s). To avoid double counting, a one-way route was taken, with at least two observers involved in each survey trip. The survey route was not randomly selected, but was based on accesibility as permitted by tidal changes. All Proboscis Monkeys detected within the same 50 m radius were reported as the same group (Bernard and Hamzah 2006).

The estimated population density formula follows the method of Aziz and Laman (2018) by which the estimated population density is derived by dividing the cumulative number of individuals sighted by the total surveyed area:

$$\textbf{\textit{Population density}} = \frac{\textit{Cumulative total number of individual sighted}}{\textit{Total surveyed area (sq km)}}$$

$$\textbf{\textit{Total surveyed area}} = \textit{Length of riverbank surveyed (km)} \times \textit{Transverse distance from riverbank (km)}$$

Bernard and Hamzah (2006) considered that the home range size is necessary to estimate the population density of Proboscis Monkey. However, as information on the home range size of the Proboscis Monkey requires a long period of observation, which could not be conducted during this study, a maximum transverse distance (potential distance travelled by the species) of 0.75 km was used (Salter *et al.* 1985; Aziz *et al.* 2015; Aziz and Laman

2018; Aziz 2019; Laman and Aziz 2019; Khan *et al.* 2021). The distance of 0.75 km was first proposed by Nightingale (1981) and was also used by Salter *et al.* (1985) in their study on the ranging behaviour of Proboscis Monkey conducted in Samunsam Wildlife Sanctuary and Bako National Park. This distance of 0.75 km was applied as a conservative estimate to standardise the ranging distance used by the Proboscis Monkey in Limbang Mangrove National Park. This distance is within the range of the species' reported daily movement (less than 1 km from the riverbank) (Medway 1977; Salter and MacKenzie 1985; Bennett and Sebastian 1988; Yeager 1991; Boonratana 2000; Meijaard and Nijman 2000; Matsuda 2008; Bismark 2010).

Species Distribution

The Proboscis Monkeys' distribution map in this study was generated by the Geographic Information System software programme (ArcMap 10.4) (Esri, 2019). Three different types of maps (heat map, population distribution and survey route) were developed to illustrate the spatial information of the species. Heat Map is a data visualisation technique that shows the population density magnitude of Proboscis Monkey. Heat Map was calculated using the Kernel Density Estimation, a non-parametric way to estimate the probability density function of a random variable. The latest forest cover map was created based on the satellite images from Landsat 8, Sentinel 2, MODIS 2016 and STRM 1-arcsecond. Other supplementary maps that were developed include the land use map from the Department of Survey and Mapping Sarawak, global mangrove distribution by UNEP-WCMC-Global 2011 and Sarawak topography map series DNMM5201.

Social Demographic Survey

A questionnaire consisting of open-ended and fixed response questions was designed to obtain data on the perception and awareness by the local community in Limbang on Proboscis Monkey's existence in their area. Surveys were conducted based on convenience, and informed consent was given by all interviewees. The questions were designed to obtained information on the (1) socio-demographics of the local community; (2) perception on the conservation of Proboscis Monkey; (3) Proboscis Monkey as a tourism attraction; and (4) consumption and hunting of Proboscis Monkey among the local community. Interview were conducted in nearby government offices, villages and residential areas, including Kg. Pabahanan, Kg. Patiambun, Kg. Limpaki, Kg. Seberang Kedai, Kg. Pahlawan, Kg. Ukong, Kg. Sembilang, Taman Bunga Raya, Kg. Sibukang and Kg. Tegarai. The information collected was then analysed using the Boosted Regression Trees for Ecological Modeling. This modelling analysis allows data to be interpreted more efficiently. The social-demographic parameters were used to identify which factors had the highest influence on the 11 perceptions/questions related to the species.

RESULTS

Population Density of Proboscis Monkey in Limbang Mangrove National Park

A cumulative distance of 223.59 km of mangrove-riverbanks was surveyed through 11 survey trips at Limbang mangroves. A cumulative total of 236 individuals from 34 groups, including three solitary individuals, were sighted. The Proboscis Monkey density in Limbang Mangroves National Park was estimated to be in the range of 1.03 – 1.78 individuals/km^2 or 0.15 – 0.25 groups/km^2. The average number of Proboscis Monkeys detected for every one-kilometre survey effort at Limbang Mangrove National Park was 1.06 individuals (21.45 ± 5.74) or 0.15 groups (3.09 ± 0.77). Within the 11 survey trips conducted, the average number of individuals and groups of Proboscis Monkey recorded was 21 and 3, respectively. The highest number of individual Proboscis Monkeys sighted was on the fourth trip of the survey, with 39 individuals from 4 groups recorded (PM 13, PM 14, PM 15 and PM 16). The largest Proboscis Monkey group had 23 individuals (PM 29) (Figure 2).

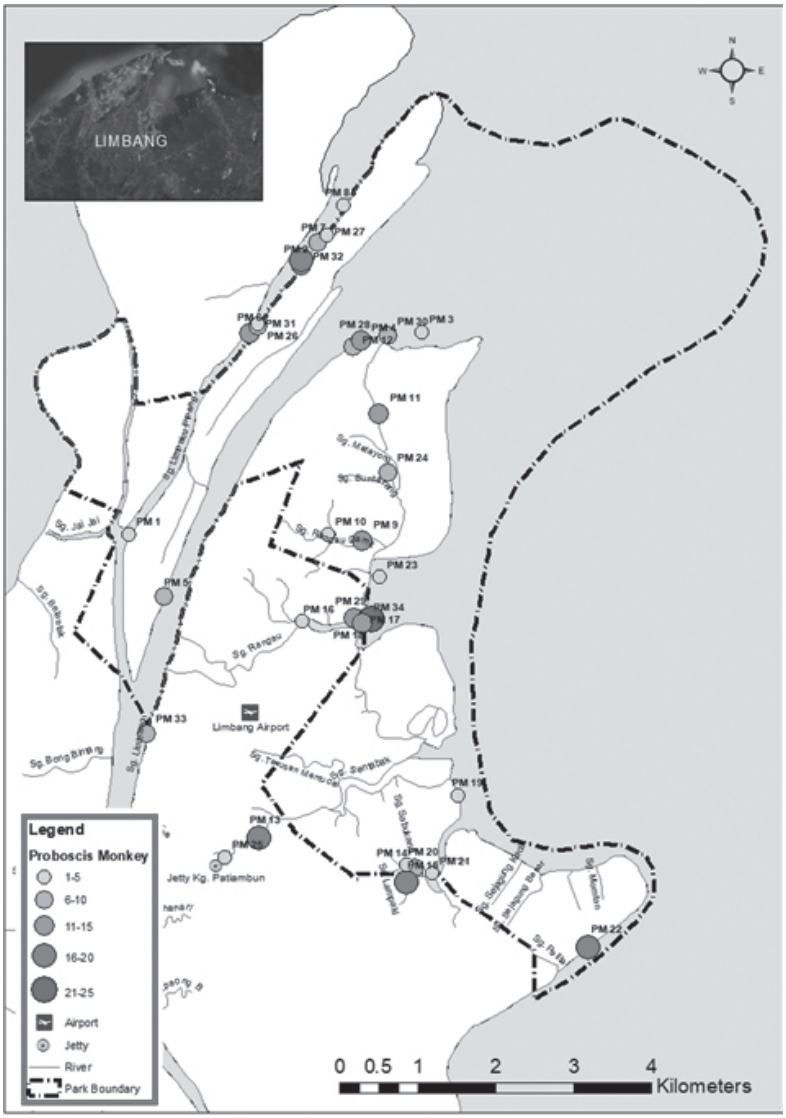

Figure 2: Group size of Proboscis Monkey in Limbang Mangrove National Park.

Local Distribution of Proboscis Monkey in Limbang Mangrove National Park

The distribution of Proboscis Monkeys at Limbang Mangrove National Park found to be evenly spread within the park boundary (Figure 3). Eleven groups of Proboscis Monkeys were sighted outside the national park boundary around Sungai Rangau, Sungai Limpaku Pinang, Sungai Limbang and Sungai Limpaki (PM 6, PM 13, PM 15, PM 16, PM 17, PM 18, PM 25, PM 26, PM 31, PM 33, PM 34). Figure 4 shows the heat map for the Proboscis Monkey population. The density of Proboscis Monkeys was found to be concentrated at the centre of the park, but the monkeys were also dispersed around the north and south boundary of the park. Out of the 34 Proboscis Monkey groups sighted, 22 groups with 146 individuals were recorded during the morning surveys. The balance of 12 groups with a total number of 90 individuals was recorded during the evening surveys. However, the t-test shows no significant difference between the numbers of Proboscis Monkey individuals recorded during the morning and evening surveys (p-value = 0.33, α = 0.05, one-tailed test).

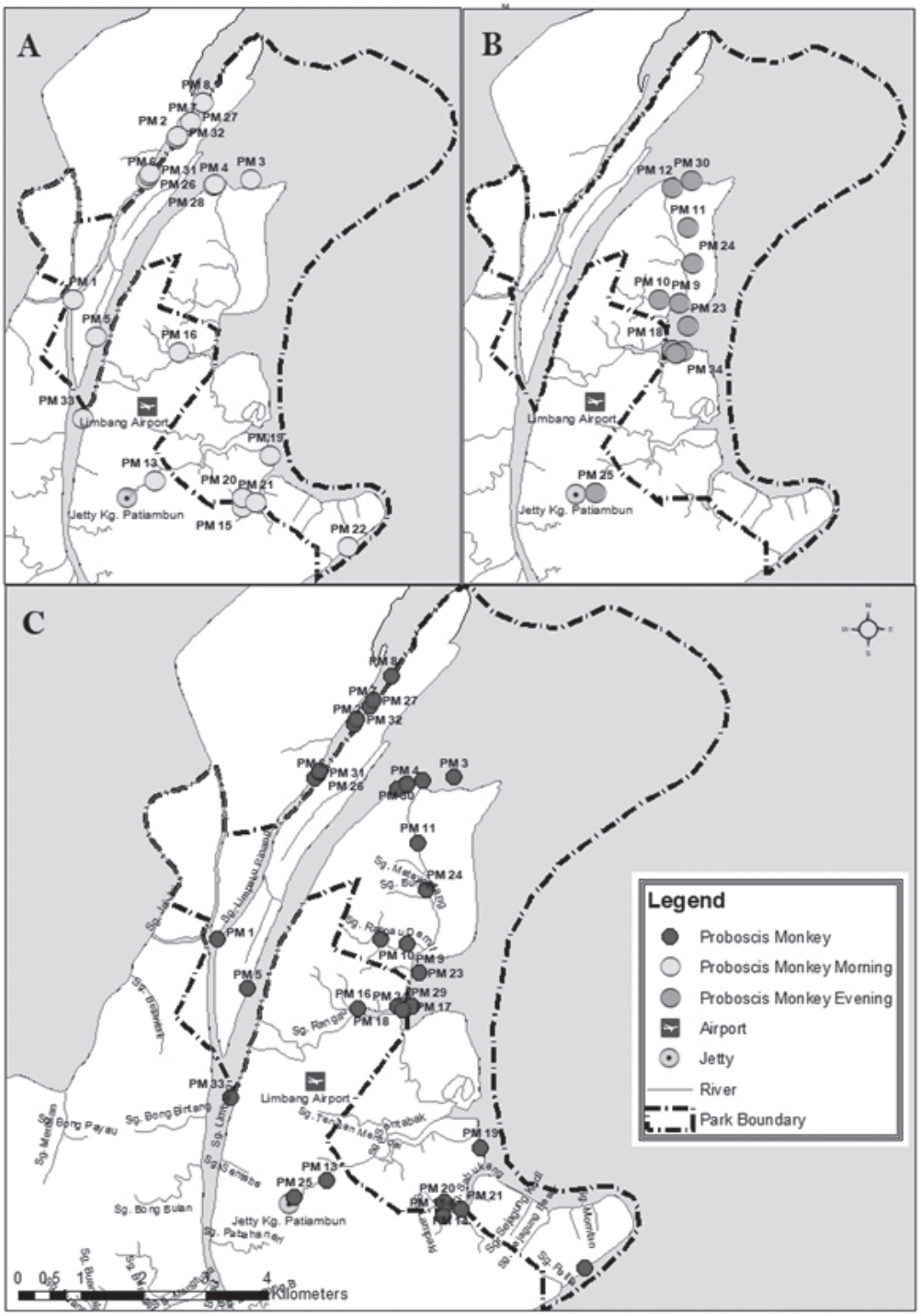

Figure 3: Distribution of Proboscis Monkey in Limbang Mangrove National Park during the: (**A**) morning survey, (**B**) evening survey, (**C**) overall survey.

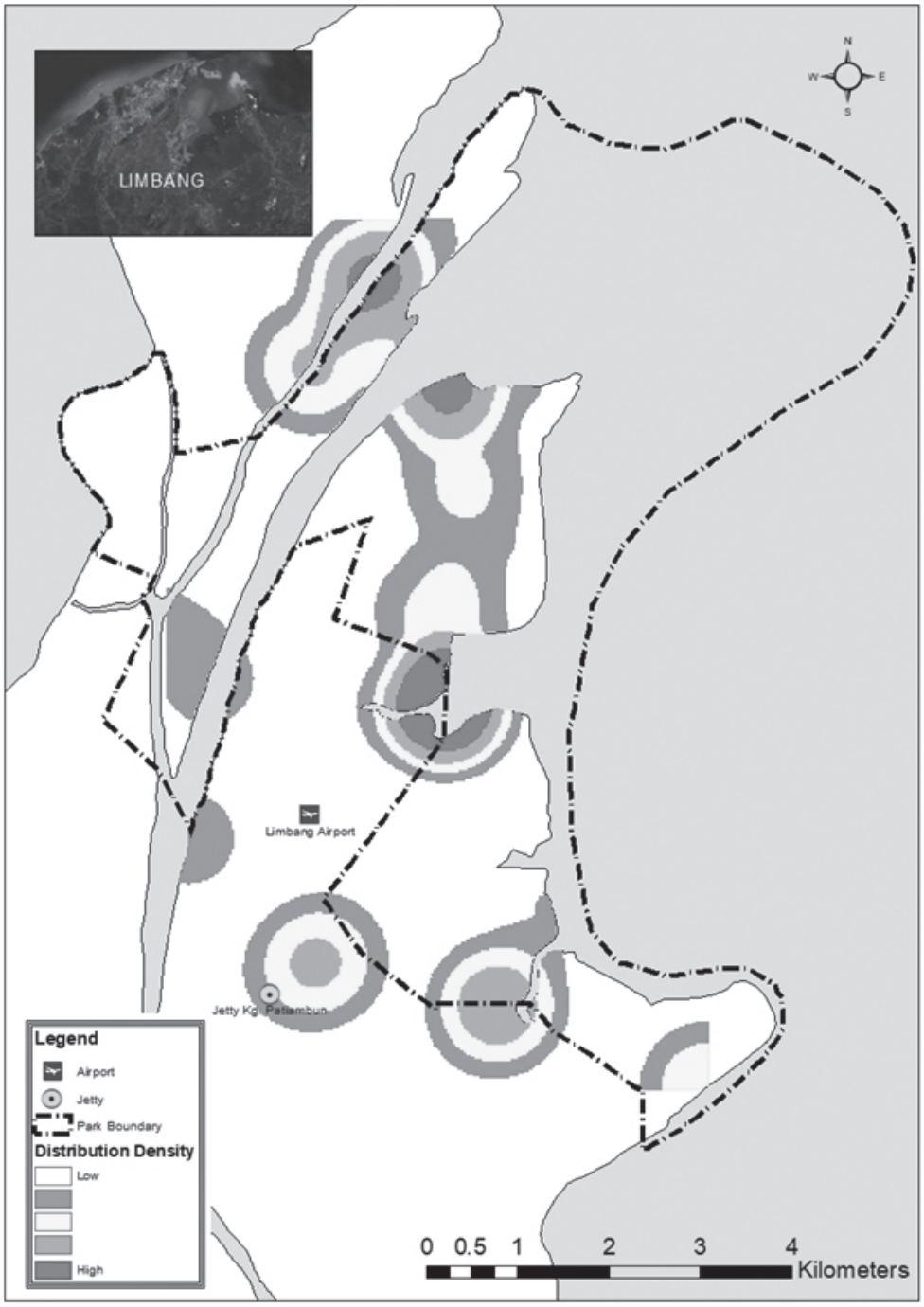

Figure 4: Heat map distribution of Proboscis Monkey in Limbang Mangrove National Park.

All the 34 Proboscis Monkey groups in Limbang Mangrove National Park were recorded within the mangrove vegetation. Mangrove trees that the Proboscis Monkey commonly used were *Sonneretia* sp. and *Avecennia* sp. Species usage of *Sonneretia* sp. (57%) was slightly higher than *Avecennia* sp. (47%). Statistical analysis shows no significant difference between habitat use of *Sonneretia* sp. and *Avecennia* sp. by individuals of Proboscis Monkey at Limbang Mangrove National Park (p-value = 0.14, α = 0.05, one-tailed test).

Social Demographic Survey

A total of 101 Malaysian respondents were interviewed using the questionnaire survey on Proboscis Monkey around the Limbang area (Figure 5). The respondents were identified as working local residents (n=79), spouses (n=21), and tourist (n=1). Of the respondents, 44.55% preferred not to disclose their origin; positive responses identified 20.80% from Kampung Pabahanan followed by Kampung Patiambun (16.83%), Kampung Limpaki (13.86%), Kampung Ulak (3.96%). Meanwhile, 7.93% preferred not to disclose their gender; among the remainder, 47.52% were male and 44.55% female. Most of them were in the 25–54 years old age group (75.25%) and, Malay/Kedayan (89.11%), and Islam (75.25%), were the greatest reported ethnicity and religion. Of 101 respondents, 79 were married, 22 single and three did not wish to disclose their marital status. More than 50% of the respondents were working as government servants and most of them had a monthly income of less than RM 2,500. Thirty-seven of the respondents had university as their highest education, while three respondents never had formal education.

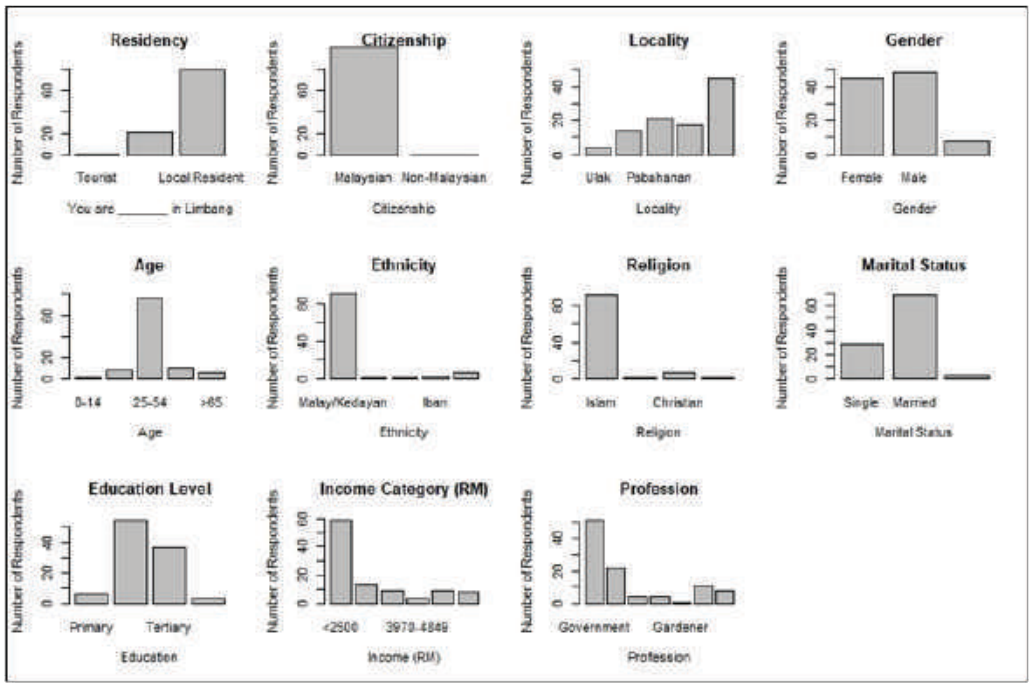

Figure 5: Demographic of the respondents in Limbang based on their residency, citizenship, locality, gender, age, ethnicity, religion, marital status, education level, income category (RM), and their profession.

From the Boosted Regression Trees for Ecological Modelling output based on the 11 perception questions that were answered by the respondents, locality (7/11 perceptions) and income (4/11 perceptions) of the respondents were the most influential factors in the survey. The respondents' locality and income influenced most of their perceptions. While religion, education and profession were the minor variables influencing the respondents' response (Table 1).

A total of 43 (42.6%) respondents had seen a Proboscis Monkey, mainly near rivers alongside the mangrove vegetation. Sixteen of them reported that they observed the Proboscis Monkey more than a year ago, while the others reported that they saw Proboscis Monkey more recently. Most of the respondents had frequently observed Proboscis Monkey between the months of July – September, while four of the respondents had observed the species throughout the year. Almost all the respondents (99%) have never hunted nor consumed the species. Only one respondent consumed Proboscis Monkey meat that was given by a friend.

DISCUSSION

Population Density and Local Distribution of Proboscis Monkey

A previous survey of Proboscis Monkey in Limbang Mangrove National Park resulted in 2.61 individuals/km² (Aziz 2019; Laman and Aziz 2019; Khan *et al.* 2021) which is higher than the current estimation with only 1.03-1.78 individuals/km². The average individual recorded per kilometre survey effort in the current study was also lower than the previous survey, which was 1.06 - 1.96 individuals/km^2. However, comparison between these estimations need to be carefully interpreted, as they lack cohesiveness in term of time-lag and survey efforts. Even though the same survey technique was applied in both cases, the differences in survey periods and survey efforts should be taken into account (Sha *et al.* 2008). The present study was more extensive, covered more areas, and involved up to three times more effort compared with the previous survey by Aziz (2019). As such, the current estimate appears reliable and representative of the study area.

Areas where habitats are intact provide a substantial variety of sleeping sites along the many tributaries; but these may change daily. Changed site-selection may increase their detection in the smaller tributaries (Bennett and Sebastian 1988). Proboscis Monkeys observed nearer to the main river system had a shorter alert distance. They appear to be shy and tend to move towards denser vegetation, compared with those in the tributaries inland, where individuals can be observed longer. Besides, the difference in the temporal detection could be partly contributed by the concentration of people nearby these areas. As been reported previously, Proboscis Monkeys avoid clear-felled tidal forest and areas around human settlement (Salter *et al.* 1985).

The largest recorded group of Proboscis Monkeys was a total of 23 individuals (PM 29). This group may have consisted of more than one harem, as more than one adult male was sighted. It is already known that Proboscis Monkeys may form a secondary social organisation level where several groups may forage and sleep together in close proximity (Bennett and Sebastian 1988; Boonratana 2002). The total number of individuals sighted during the morning was 62 % greater than individuals recorded during the evening, since Proboscis Monkeys they are very sensitive to anthropogenic activities (Wardatuttthoyyibah 2019). The difference, especially along the main rivers, suggests that the monkeys' activity can be influenced by local people's boat traffic during the day for fishing and transportation. Proboscis Monkeys were not recorded within or nearby human settlements.

Proboscis Monkeys were recorded along most of the tributaries, and were evenly distributed throughout the mangrove, including the edge of the National Park boundary. The density of Proboscis Monkey in Limbang Mangrove National Park appears to be concentrated at the centre of the mangroves (river mouth of Sungai Rangau) with 42 individuals of Proboscis Monkeys from four different groups recorded within a 500 m radius. A substantial proportion of this area is not within the protected Limbang Mangrove National Park (Figure 4). Individuals were also observed outside the Park boundary, confirming that this monkey can cross rivers and traverse mangrove mud (Bennett and Sebastian 1988; Harding 2015). Monitoring the population outside Park bounds should be included in future surveys. To protect the population, an extension to the Park could be proposed. While medium-sized population densities (10-17 individuals) were primarily recorded at interior parts, closer to

the upstream of the river (Sungi Lampaki, Sungai Limbang and Sungai Sentabak). There were also smaller independent groups (1- 9 individuals) of Proboscis Monkey found within the surveyed area. Usually, these small groups were separated from other groups by more than 500 m distance. Proboscis Monkeys were also distributed independently upstream at the inland part of Sungai Rangau Damit. During the survey, several groups of Long-tailed Macaques (*Macaca fascicularis*) were also sighted, and some of their range overlapped (15%) with the Proboscis Monkeys' areas.

Riverbanks are core habitats for the Proboscis Monkey (Bennett 1986; Bennett and Gombek, 1993). The main factor that determined the patterns of habitat use by the Proboscis Monkey at Limbang are the food sources that are closely associated with riverbanks (Tuen and Pandong 2007; Matsuda 2008). The utilisation of the two mangrove plant species by the Proboscis Monkey in Limbang Mangrove National Park did not significantly differ between the mangrove stands. The habitat utilisation of Proboscis Monkey in Limbang Mangrove National Park appears to be influenced by *Sonneretia* sp. and *Avicennia* sp. These trees are important to the species as they are used for resting, sleeping, and their foliage is a primary food resource (Kawabe and Mano 1972).

Results of Questionnaire

The questionnaire survey on perception on conservation and ecotourism showed that most of the local communities' perceptions were associated with their locality and income. Our survey has provided some essential and novel quantitative data on the relationship between local people and Proboscis Monkeys near the Limbang Mangroves. At the same time, this exercise also yielded a wealth of quantitative details to better understand the current perceptions, guiding appropriate conservation strategies. Surprisingly, even though 99% of the respondents were local residence of Limbang or spouses, only 42.57% of the respondents had seen Proboscis Monkey, despite the species' wide distribution in the mangroves. The lack of familiarity potentially influenced their appreciation and support for conservation efforts of this endemic species.

However, when answering the questions regarding the important role of proboscis monkey in the ecosystem and promoting tourism (Perception 2, Perception 3, Perception 4, Perception 5), more than 50% of the respondents supported these perceptions, with locality and income as the most influential factors. When answering perception number six ('I do not like to consume Proboscis Monkey's meat') most respondents strongly agreed, probably because 91% of the total respondents were Muslims. Besides being influenced by religion, it is also a customary prohibition for Muslims to consume such kinds of meat (Aziz and Laman 2018). Furthermore, for perceptions related to the conservation towards Proboscis Monkey (Perception 7, Perception 8, Perception 9, Perception 10, and Perception 11) received more than 50% 'Agree' and 'Strongly Agree' answers. Most of the respondents agreed that this species plays an essential role in the ecosystem and supported awareness programs in schools to help promote conservation efforts in Limbang.

CONCLUSION

Considering our findings, Limbang Mangrove National Park should be given conservation and ecotourism priority. Any proposed development within the protected area should carefully consider the Proboscis Monkeys' spatial and ecological requirements. It will be a pity if the main attraction is lost as a result of poor planning without considering the long-term persistence of this species in this area. The relevant agencies should take this opportunity to enhance conservation efforts towards Proboscis Monkey in Limbang Mangrove National Park through education and awareness campaigns. Proper conservation of this species, paired with sustainable ecotourism, will bring economic growth to the local community.

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Table 1: List of answers, Boosted Regression Tree (BRT) models that relate the respondents' demographics on perceptions. The respondents 447 demographics used as the variance of the BRT model. Locality and income were the most influential demographic parameter towards the 448 respondent's perception while answering the survey.

Most Answered	BRT Model (%)									
	Perception 1: Consuming Proboscis Monkey meat can strengthen the body.									
Unsure	Locality	Income	Status	Age	Education	Ethnicity	Profession	Residency	Gender	Religion
	50.94	23.65	18.49	3.74	1.22	1.00	0.62	0.27	0.07	0.00
	Perception 2: Proboscis Monkey plays an important role in ecosystem.									
Agree	Locality	Income	Profession	Gender	Residency	Education	Status	Age	Ethnicity	Religion
	50.44	20.72	18.42	5.76	3.48	0.46	0.37	0.20	0.15	0.00
	Perception 3: Proboscis Monkey plays an important role in promoting tourism.									
Strongly Agree	Locality	Income	Profession	Gender	Residency	Age	Ethnicity	Religion	Status	Education
	92.28	7.50	0.16	0.07	0.00	0.00	0.00	0.00	0.00	0.00
	Perception 4: The tourism industry (Proboscis Monkey) can be enhanced by building jetty in the mangrove forest.									
Agree	Locality	Income	Age	Education	Status	Residency	Gender	Ethnicity	Religion	Profession
	82.81	14.50	2.03	0.43	0.24	0.00	0.00	0.00	0.00	0.00
	Perception 5: Tourism activities regard Proboscis Monkey can increase the local's economy.									
Agree	Income	Locality	Age	Status	Sector	Residency	Gender	Ethnicity	Religion	Education
	76.79	21.39	1.32	0.36	0.14	0.00	0.00	0.00	0.00	0.00
	Perception 6: I do not like to consume Proboscis Monkey's meat									
Strongly Agree	Income	Locality	Profession	Gender	Residency	Age	Ethnicity	Religion	Status	Education
	38.99	36.74	24.19	0.08	0.00	0.00	0.00	0.00	0.00	0.00
	Perception 7: Hunting and selling of Proboscis Monkey can damage Proboscis Monkey populations in the long term.									
Strongly Agree	Income	Locality	Gender	Age	Profession	Residency	Ethnicity	Religion	Status	Education
	51.68	21.45	15.40	8.29	3.17	0.00	0.00	0.00	0.00	0.00

Perception 8: Deforestation cause more negative impact on Proboscis Monkey population compared to hunting activity.

	Income	Profession	Gender	Locality	Education	Residency	Age	Status	Ethnicity	Religion
Agree	57.10	30.43	3.23	2.83	2.32	1.92	1.66	0.50	0.06	0.00

Perception 9: Wildlife law is necessary for Sarawak to protect Proboscis Monkey.

	Locality	Age	Profession	Status	Income	Education	Residency	Gender	Ethnicity	Religion
Agree	91.47	4.83	3.12	0.38	0.16	0.00	0.00	0.00	0.00	0.00

Perception 10: Besides the Sarawak Wildlife Law, Proboscis Monkey also needed to be protected at the village level.

	Locality	Income	Age	Profession	Residency	Gender	Ethnicity	Religion	Status	Education
Agree	98.75	0.93	0.21	0.11	0.00	0.00	0.00	0.00	0.00	0.00

Perception 11: Awareness program in schools will help to increase the effort to conserve the Proboscis Monkey.

	Locality	Income	Age	Gender	Profession	Residency	Ethnicity	Religion	Status	Education
Agree	75.58	14.96	6.29	1.62	1.56	0.00	0.00	0.00	0.00	0.00