

**Pilot survey of nocturnal primates,
Tarsius bancanus borneanus (Western tarsier)
and
Nycticebus coucang menagensis (Slow loris)
in peat swamp forest, Central Kalimantan,
Indonesia.**

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Abstract.

A survey of the data deficient nocturnal primate species the Western tarsier, *Tarsius bancanus borneanus*, and the slow loris, *Nycticebus coucang menagensis*, was carried out in a peat swamp forest in Central Kalimantan, Indonesia. A line transect method was chosen to survey these two species. A distance of 50.850km was walked, covering a pre-existing transect system twice. Limited transect walks were also carried out in two other forest habitats, low interior forest and tall interior forest. Population density estimates were calculated at 0.004 individuals/km² for *Nycticebus coucang menagensis* and 0.003 individuals/km² for *Tarsius bancanus borneanus*. Habitat characteristics were recorded in five 10 m by 10 m plots set up along seven transects in the peat swamp. No significant difference was found between the transects in the average diameter at breast height of trees per plot, total number of trees per plot or number of trees of diameter at breast height of between 1 cm and 4 cm. This diameter at breast height of between 1 cm and 4cm was thought to be the preferred size of support for tarsier locomotion. Although no significant difference was found between the transects in this habitat characteristic, over 66% of the trees measured in the plots were between 1 cm and 4 cm in diameter and breast height which suggests this is suitable habitat for tarsiers in terms of the availability of locomotive supports of a preferred size. Due to problems with the methodology it is unlikely that the density estimates calculated in this study are accurate. Further studies into the densities of the Western tarsier, *Tarsius bancanus borneanus*, and the slow loris, *Nycticebus coucang menagensis* are required for this area of peat swamp forest.

Introduction.

Two nocturnal primates are found on the island of Borneo : the slow loris, *Nycticebus coucang menagensis*, and the western tarsier, *Tarsius bancanus borneanus*. Both these nocturnal species are classed as data deficient on the IUCN Red List (IUCN, 2000). The purpose of this study was to begin to fortify this lack of data by carrying out a pilot survey of both *N. coucang menagensis* and *Tarsius bancanus borneanus* in peat swamp forest, Central Kalimantan, Indonesia.

Study Species.

The slow loris, *Nycticebus coucang*, belongs to the family Lorisidae (Brandon-Jones et al, 2004). This nocturnal primate has a head and body length of 265-380mm and is a quadrupedal slow climber (Rowe, 1996). As well as being found on the island of Borneo, in both the Malaysian states of Sabah and Sarawak and in Kalimantan (Indonesian Borneo), the range of *Nycticebus coucang* also includes the Malaysian peninsular and the Indonesian island of Sumatra. However, the subspecies *Nycticebus coucang menagensis* is found only on Borneo (Groves, 1998). Although this is a data deficient species, a number of wild studies of *N. coucang coucang* have been undertaken. Barrett (1981) carried out behavioural studies of the slow loris in Peninsular Malaysia. Wiens (2002) also carried out behavioural studies of the slow loris (subspecies *Nycticebus coucang coucang*) in Peninsular Malaysia, while Fitch-Snyder and Thanh (2002) carried out a preliminary survey of lorises (*Nycticebus bengalensis* and *Nycticebus pygmaeus*) in Northern Vietnam. The presence of *N. coucang menagensis* has been confirmed in Kalimantan and in peat swamp forest (e.g. Chivers and Burton, 1988), however this has been in terms of general primate surveys

and presence or absence lists (although Mackinnon, 1986 did attempt to estimate density) rather than in specific nocturnal surveys. In the case of these reports it is not always apparent if the species was actually seen or if some other type of resource was used to suggest its presence or absence.

It is important that the data deficient status of *Nycticebus coucang* is rectified through nocturnal surveys. There is also another cause for concern with this species. *Nycticebus coucang* is often found in illegal pet trade markets (Schulze and Groves, 2004) and *N. coucang* body parts are used for medicinal purposes in Southeast Asia (Huynh, 1998). Due to the lack of sufficient data we do not know what effect this illegal trade is having on *N. coucang* numbers in the wild, therefore not only is investigation into the trade needed but also density surveys of loris habitat need to be carried out.

The Western tarsier, *Tarsius bancanus*, is completely carnivorous, living on a diet of arthropods, birds, bats and snakes (Niemitz, 1979). It is a small-bodied primate, with a head and body length of 128mm. It is also a vertical climber and leaper (Rowe, 1996). *Tarsius bancanus* belongs to the family Tarsiidae (Brandon-Jones et al, 2004). This family is made up of a single genus *Tarsius*. At present 7 species are recognised (Brandon-Jones et al, 2004). The Tarsiidae are only found in South East Asia: in Indonesia, the Philippines and the Malaysian states of Sabah and Sarawak. *Tarsius bancanus* is only found on the islands of Borneo and Sumatra with the subspecies *T. b. borneanus* only found on the island of Borneo (Groves, 1998). Previous research into this subspecies in the wild is now twenty years old, taking place in Malaysian Borneo in the 1970s and 1980s. Fogden (1974) undertook the first wild study of *T. b.*

borneanus. Since then, Niemitz (1979, 1984) studied *T. bancanus* in a semi-wild environment and Crompton and Andau (1986, 1987) also undertook wild studies. In a similar case to *N. coucang menagensis*, the presence of *T. b. Tarsius bancanus borneanus* in Kalimantan and in peat swamp forest has also been confirmed (e.g. Chivers and Burton, 1988), but again this is more in terms of general presence or absence lists rather than specific nocturnal surveys.

Twenty years ago only three species of tarsier were recognised, *Tarsius bancanus* (Horsefield's tarsier, Western tarsier), *Tarsius syrichta* (Philippine tarsier) and *Tarsius spectrum* (Eastern tarsier/Spectral tarsier) Research into the differing vocalisations and morphologies of populations of *T. spectrum* (the Spectral tarsier) lead to four other Sulawesi species being recognised. Since no further research has been carried out in the last twenty years on the data deficient tarsier species *T. bancanus* Brandon-Jones et al (2004) believes that Borneo is now a priority area for tarsier surveys. At present a single subspecies of tarsier is recognized for the whole of Borneo, but with the difficulty in uncovering taxonomic diversity through museum specimens, and the fact that many other Bornean mammals show regional variation, further subspecies of tarsier may exist on this island. The first step in this process is to locate where different populations of tarsiers exist, through surveys such as this.

Kalimantan.

Central Kalimantan (also known as Kalimantan Tengah) is made up of the hills and plains of southern Borneo. It is mostly of lowland elevation with large, south-flowing rivers. There are high mountains along the northern watershed boundary. Mangrove, heath and swamp forests grow on the poor soils of the south while lowland

dipterocarp forests can be found in the north. There are 13 species of primate in Borneo and at least 11 species in Kalimantan Tengah (Chivers and Burton, 1988).

There is a threat that increases the need for surveys of both *N. coucang* and *T. bancanus* in Kalimantan, Borneo. Both nocturnal species inhabit forested areas and it has been estimated that the rate of deforestation in Indonesia since 1985 is up to 12000 km² per year (Hamer et al, 1997). Therefore, not only are these species losing habitat but without sufficient data we do not know the effect this deforestation is having on their populations. As previously mentioned, both *N. coucang* and *T. bancanus* have been confirmed to occur in peat swamp forest. Since peatland accounts for over 6 million hectares of the lowlands of Kalimantan (Rieley et al, 1996), and taking into account the levels of deforestation occurring in Indonesia, it is necessary to confirm properly that the two nocturnal primates found in Kalimantan do inhabit peat swamp forest and to find out the densities that occur there. Peat swamp forest is fast becoming the only remaining undeveloped forested landscape in the lowlands of Kalimantan, and this makes it of high importance for animal conservation (Page et al 1997).

Surveys and Study Design.

Conservation organisations such as the World Conservation Union (IUCN) make assessments of a species' conservation status and evaluate whether a species is at risk of extinction and how at risk a species is (IUCN Red List, 2004). One of the steps involved in making conservation assessments is working out the distribution of a species. There are a number of different types of evidence researchers can use to discover whether a species is present or absent in an area. This can be done through direct observations, indirect observations (tracks, faeces, nests, carcasses, feeding signs, calls), captured/killed animals (if their origin can be established) and/or accurate information from local people (Ross and Reeve, 2003).

It is also important to know not just if a species is present in an area, but also how many animals are found in an area. For conservation purposes an estimate of the population size of a species is often required to help evaluate the status of a species. A population density estimate can also be used as a basis for future monitoring of any changes in the size of the population, including finding out if a population is declining. A final reason why a population density estimate is useful for conservation purposes is to determine the habitat requirements of a species (by comparing different habitat areas) and therefore identify priority areas for conservation (Cowlshaw and Dunbar, 2000; Sutherland; 1996). The Sebangau National Park itself is an example of a priority area of conservation because the National Park was designated primarily because this peat swamp region contains an important population of the endangered orangutan (*Pongo pygmaeus*) (WWF Indonesia, 2004).

Population density estimates can be calculated through the use of surveys. There are a number of different types of survey. A “true census” calculates the size of a population by making a total count of all the animals in a study area. However, this type of survey is only accurate if a population is closed and if animals can be identified individually (Greenwood, 1996). If a total count is not possible then the density of a population can be estimated from surveys of a sample of smaller areas. These types of surveys can be plot sampling, strip transects or line transects (Ross and Reeve, 2003).

Plot sampling involves making total counts in quadrats and is good for inanimate objects that are easy to mark and therefore are less likely to be double counted. Similarly, strip transects involve counting all of the individuals in the transect strip (Ross and Reeve, 2003). For species that are not inanimate and possibly difficult to catch, line transects can be used because part of the assumption of line transect methodology is that not all the animals in an area will be detected (Greenwood, 1996).

An example of line transects is DISTANCE sampling (Buckland et al, 1993). Distance sampling involves counting as many animals as possible from a line (or a point) within an area. It uses the assumption that only a proportion of the animals will be seen and this proportion is used to work out an estimate of the total number of animals. Other assumptions used in this methodology are that objects on the line are never missed, objects do not move before being detected, objects are not counted twice in a single transect walk, distances and angles are measured accurately, sightings are independent events and that sufficient sightings are made for an accurate estimate of the detection function (60 - 80 individual sightings).

It seems that line transect methods are the most suitable for a pilot survey of nocturnal primates for a number of reasons. Firstly, neither *T. bancanus* or *N. coucang menagensis* are inanimate species, therefore successful total counts are unlikely. Secondly, there is no guarantee that all animals in a strip transect would be seen. Therefore line transect methods seem most suitable.

Charles-Dominique and Bearder (1979) suggest line transects as a method for locating and observing all loridid species in their natural habitat. However, they do point out that because of the difficulty in surveying equatorial rain forest, where these loridids are, found a number of parameters need to be taken into consideration. Duckworth (1998) also discusses the limitations and problems with using line transects to estimate populations of nocturnal forest animals. These limitations include the difficulty of detecting all nocturnal animals on the transect line, which is a major assumption of DISTANCE sampling. Another limitation he points out is that sample sizes need to be between 60-80 sightings, although Ross and Reeve (2003) state that at the very least 40 individual sightings can be used to calculate density estimates. Either way, if this figure is not achieved then DISTANCE cannot be used.

To allow data and results to be compared between sites and investigators, methods should be standardised (Struhsaker, 1981) and by at least attempting to use DISTANCE sampling this is more likely to be achieved. It is not possible before a study begins to know how many animals you will encounter, therefore it is better to survey according to DISTANCE sampling on the chance that you will encounter enough animals to be able to calculate densities using this method. Duckworth (1998)

himself points out that in many cases there is an urgent need for at least a rough estimate of the status of a species in an area and that accurate population density measures are the best way of doing this if they are possible.

Surveys and Habitat Characteristics.

Another part of carrying out surveys is to determine habitat requirements for a species (Cowlshaw and Dunbar, 2000). One way of studying this is to link habitat characteristics with an animal's phenotypic traits (Ganzhorn, 2003). In the case of smaller mammals it has been shown that their distribution is often associated with the availability of suitable habitats (Entwistle and Stephenson, 2000). If there is a patchy distribution of microhabitats then small mammals with specific microhabitat requirements may also show a patchy distribution (Entwistle and Stephenson, 2000). A number of studies have been carried out on nocturnal primates and their microhabitat use, for example, Rendigs et al (2003) looked at microhabitats in the context of forest structure and compared this to the distribution of mouse lemurs (*Microcebus* spp.) and Nekaris (2005) looked at the influence of forest structure on the population density of the red slender loris (*Loris tardigradus*). In the case of tarsiers, Merker (2003, cited in Merker et al, 2005) found that the population density of Dian's tarsier (*Tarsius diana*) was highest in areas of habitat with a high availability of plant supports for locomotion. To help conserve areas of suitable habitat for species it is important to know what types of habitat are most suitable and what characteristics of the habitat make it suitable.

For these reasons, the following pilot study of nocturnal primates, *Tarsius bancanus borneanus* (Western tarsier) and *Nycticebus coucang menagensis* (Slow loris), using line transect methods, was carried out in the peat swamp forest of the Sebangau National Park, Central Kalimantan, Indonesia.

Methods.

Study Site.

This study was carried out at the Setia Alam Field Station situated just inside the Sabangau National Park, 3 km from the Sebangau River, one hour from the provincial capital of Palangkaraya, Central Kalimantan, Indonesia (see figure 1). Setia Alam Field Station lies $2^{\circ} 20' 42''$ south and $114^{\circ} 2' 11''$ east. The Sabangau National Park, designated in November 2004, covers 568 000 hectares of peat swamp forest between the Sabangau and Katingan Rivers in Central Kalimantan. The area is an old logging concession and was selectively logged for thirty years up until 1996.

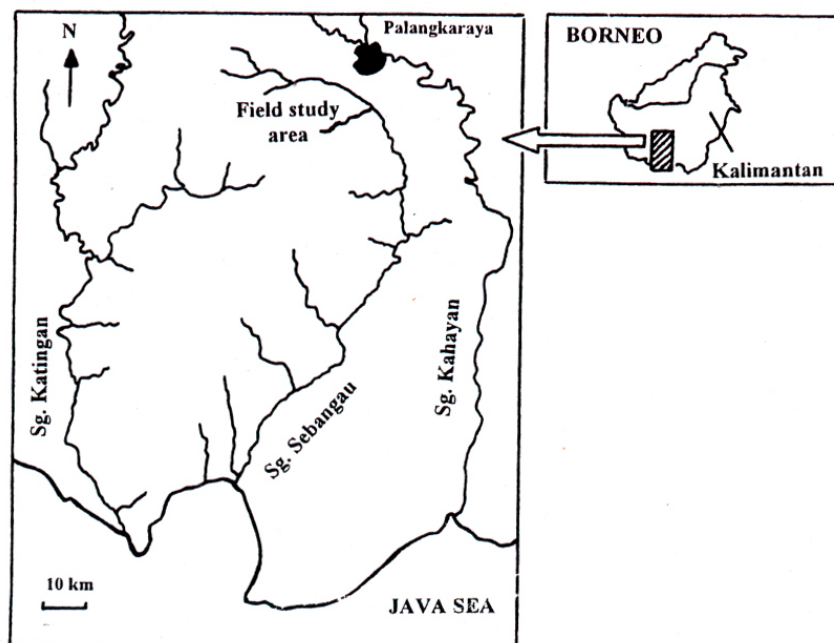


Figure 1:
Location of Setia Alam Field Station, showing the Sebangau River
(sourced from Morrogh-Bernard et al, 2003).

Two loris and three tarsier sightings have occurred during daytime hours at this study site in the last four years (Simon Husson, personal comm.) but at present neither *T. bancanus* or *N. coucang* is documented in the literature as occurring in this region (Page et al, 1997). The other primates found in the Sabangau region are the orangutan (*Pongo pygmaeus pygmaeus*), agile gibbon (*Hylobates agilis*), long-tailed macaque (*Macaca fascicularis*), pig-tailed macaque (*Macaca nemestrina*) and the red leaf monkey (*Presbytis rubicunda*) (Page et al, 1997). A number of other nocturnal mammals are found in this peat swamp forest including the data deficient Malaysian sun bear (*Helarctos malayanus*) (IUCN Red list, 2004), pangolin (*Manis javanicus*), marbled cat (*Felis marmorata*), leopard cat (*Felis bangalensis*), bearded pig (*Sus barbatus*), common palm civet (*Paradoxurus hermaphoditus*), Malay civet (*Vierra tangalunga*) and the small-toothed palm civet (*Actogalidia trivirgata*) (Page et al, 1997).

The mixed peat swamp forest where Setia Alam is located is a tall, stratified forest. The upper canopy reaches heights of 35 metres, with a closed canopy layer between 15 and 25 metres and an open layer of smaller trees between 7 and 12 metres in height (Page et al, 1999). Two other forest types also exist in the Sabangau catchment area. These are low interior forest, located 6km from the Sabangau River and tall interior forest, located 12km from the Sabangau River (Shepherd et al, 1997).

Transect System.

The 2 km² study area is made up of pre-cut transects. Transects running north to south are labelled from A to H while transects running from west to east are labelled according to their distance from base camp (for example 0.4 km, 0.8 km). Each

transect is marked at 25 m intervals with flagging tape. Transects have also been cut in the low pole forest and tall interior forest, marked at 50 m intervals with flagging tape. The set of transects in the low interior forest start 7 km from Setia Alam Field Station. There is a satellite camp (pondok) and a set of transects covering 5.2 km. The set of transects in the tall interior forest start 12.5 km from Setia Alam Field Station, where there is another satellite camp (pondok), and cover 5.5 km.

Night Surveys.

Line transect surveys were carried out between 20th May – 5th August 2005 using the pre-existing transect system. Surveys began between 18:10 - 19:00 and finished between 22:40 - 03:00. The transects walked each night were randomly selected to avoid bias (Struhsaker, 1981) by selecting transect numbers out of a hat.

Due to time constraints and the accessibility of other forest types the main part of this research was carried out in the main peat swamp study area. Two opportunistic trips to the low pole forest and tall interior forest were carried out but less distance was surveyed in these areas.

Line transects have been used by a number of other researchers to provide density estimates for *N. bengalensis* and *N. pygmaeus* (Fitch-Snyder and Thanh, 2002), *N. coucang coucang* (Barrett, 1981, 1984) and other Lorisine species (Kar Gupta, 1998; Nekaris, 2002; Nekaris and Jayewardene, 2004), although these all use slightly different methodology.

Previous density estimates for *T. bancanus* have been calculated using home range size information. Since the aim of this pilot survey was to provide density estimates not the home range size line transects were chosen as the survey method. Gursky (1998) used a modified form of fixed point count and quadrat census methods to work out numbers of *T. spectrum* and *T. diana* groups present per hectare. Both these species give loud calls from their sleeping site at dawn and these calls can be used to locate the individuals (Gursky, 1998). *Tarsius bancanus* does not perform these dawn vocalisations (Niemitz, 1984) and there is no peak in calling activity early in the morning when the animals return to their sleeping sites (Crompton and Andau, 1987) so this method of estimating density is not applicable for this species. A number of transect walks were carried out between 01:00 and 06:30 in an attempt to check whether the tarsiers did call more at dawn, although again due to time constraints I was unable to carry out extensive surveys to test this.

The timing of the surveys was chosen because both species are nocturnal and become active around the time of sunset. Wiens (2002) found that *N. coucang coucang* became active soon after sunset and remained active for most of the night until sunrise. Similarly, Niemitz (1984) and Crompton and Andau (1987) report that *T. bancanus* becomes active around twenty minutes after sunset. At Setia Alam, sunset begins at 16:30, with civil twilight occurring at 16:52 (Thomas, 2003).

Transects were walked at a speed of 400 m/hr. In other surveys of lorises (line transects have not been previously used to locate tarsiers) transects were walked at speeds of 500 m/hr (Nekaris and Jayawardene 2004), 0.5-1.3 km/hr (Duckworth 1994) or no speed of walking was given (Fitch-Snyder and Thanh, 2002 ; Singh et al, 2000;

Singh et al, 1999; Barrett, 1981). Before beginning my survey I tested walking at a number of different speeds including 200 m/hr, 400 m/hr and 500 m/hr. I discovered that walking 400 m/hr was the best compromise between being able to adequately search the transect and covering as much distance as possible.

At the beginning of each survey the transect, date, starting time, and participating observers were recorded. The following information was recorded for each sighting:

- Time of sighting
- Perpendicular distance from the transect to the animal
- Number of individuals
- Height of individuals with respect to the ground
- Activity when first detected
- Species of plant the animal was located in.

The transect, date, starting time, participating observers and time of sighting were recorded so that information on each transect walk and sighting could be easily identified in field notes. The perpendicular distance was recorded to allow for the calculation of a detection function, had it been possible to use DISTANCE sampling to calculate density estimates (Buckland et al, 1993). The number of individuals was recorded for each sighting to begin building up data on the sociality of *N. coucang m.* The height of the individuals with respect to the ground was recorded as a basic measure of which level of the forest cover was being used by lorises. The species of plant the animal was located in was recorded in an attempt to start collecting information on which plant species are used by lorises in this region. The activity of

the sighted individual when first detected was recorded. (The collection of similar sighting information is suggested in Struhsaker, 1981).

Direct sightings of *T. bancanus* were recorded along with the following information:

- Time of sighting
- Perpendicular distance from the transect to the animal
- Number of individuals
- Height of individuals with respect to the ground
- Activity when first detected
- Species of plant the animal was located in.

This information was collected for the same reasons as discussed above for slow loris sightings. Although *T. bancanus* does not duet in the morning they do vocalize (Niemitz, 1984) and these vocalisations were recorded as presence of tarsier (with the same weighting as a direct sighting) when the individual itself could not be located.

Search Techniques.

I intended to use red torchlight to locate the tarsiers and lorises. However I found that this provided insufficient light to penetrate the forest undergrowth so white light was used. Barrett (1984) similarly points out that because of the diminished intensity of red light, in tropical rainforest the loss of light caused by the closed canopy often means it is necessary to use white light instead of red. Wiens (2002) used a 4.5 –V headlamp for observations and mentions nothing about using red light. Both sides of the transect line, as well as the transect line itself, were swept with the torch beam.

Torches used were Petzl Zoom 4.5V headlamps with halogen bulbs. A larger ABC Teletite Wide and Beam torch was also used.

All transects were walked by a group of two people: myself and a local assistant, except for the low pole forest and tall interior forest transects where, due to time constraints, some of the transects were walked by two trained local assistants. Two observers walked all transects, firstly for safety reasons and secondly so that there were two opportunities to detect the study species. Duckworth (1998) points out that many animals, even those with bright eyeshine, are not detected during nocturnal surveys because they are obscured by vegetation but that a second observer may detect these missed individuals.

Nycticebus coucang can be located by its strong orange-red eyeshine caused by the tapetum lucidum, a reflective layer at the back of the eye. This eyeshine is very similar to that of other sympatric species and so other characteristics were considered during species identification (Schulze, 2004) including slow-climbing movements, hiding of the face and eye-blinking patterns. (Wiens, Cited in Schulze, 2004).

Tarsius bancanus does not have a tapetum lucidum and so cannot be located through eye shine, but rather by spotting an individual in the light beam or through its calls, as discussed earlier. Crompton and Andau (1986) found that 76% of their observations of tarsiers were below 1 m. Therefore this part of the forest under storey was thoroughly checked with the torch beam.

Density Estimate Calculations.

Census methods should be standardised to minimise variables and allow data and results to be compared between sites and investigators (Struhsaker, 1981). In this way, the methods used to calculate density estimates should also be standardised. This is one advantage of DISTANCE sampling, which it was my original intention to use to calculate the density estimates for both *N. coucang menagensis* and *T. bancanus borneaus*. However, DISTANCE sampling requires at the very least 40 individual sightings (Ross and Reeve, 2003). Buckland et al (1993) actually state a minimum of 60-80 individual sightings. This number of sightings was not found for either species in my study.

No previous density estimates for tarsiers have been calculated using line transect methods, and the previous line transect method for a *Nycticebus coucang coucang* study (Barrett, 1984; or Barrett, 1981) doesn't specify the equations used to calculate density estimates. Density estimates were calculated following Greenland (1996) (and mentioned by Sutherland, 1996).

Duckworth (1998) suggests that until techniques for calculating densities can take into account the problems associated with nocturnal transect surveys the information gathered from nocturnal surveys should be presented as "contact frequencies" and contextual information. For this reason I have included a Table of Effort, listing the transects surveyed, the length of each transect, the survey effort for each transect, the species encountered for each transect, group size, plant species individual was detected on and additional notes.

Habitat Characteristics.

In the field studies carried out on *T. bancanus*, a number of researchers have looked into the types of supports used by tarsiers in locomotion. Niemitz (1984) measured the initial and terminal supports of Bornean tarsiers, as well as 60 trees at each netting site. He found that “while there was no striking difference between trees present and trees chosen” the tarsiers chose trees of a diameter 3-4 cm 2.4 times more than they occurred. He stated that there is a clear preference for supports of 4 cm or smaller.

Similarly, Crompton and Andau (1986) found that the mean size of support used by *T. bancanus* in their study was 2.8 cm, with the most frequent single category being a diameter of 2 cm. They also found that 65% of the supports being used by tarsiers were under 3 cm in diameter. However, they did not measure habitat characteristics to see the availability of each support size but did state that they think their study site and that of Niemitz (1984) are not very different in habitat structure.

The studies by Niemitz (1984) and Crompton and Andau (1986) suggest that trees of a smaller diameter are very important for tarsier locomotion. This in turn suggests that habitats containing supports of the preferred size for tarsier locomotion will be more suitable for tarsiers than habitats containing less supports of the preferred size.

However, trees smaller than 10 cm DBH (diameter at breast height) are rarely considered in vegetation sampling (Ganzhorn, 2003). This is reflected in the previous work on vegetation in the Sabangau region, which has focused on trees of DBH ≥ 7 cm (Page et al, 1999). Therefore, I decided carry out a vegetation study using plots to measure trees with a DBH of ≥ 1 cm to see how suitable the habitat of the Setia Alam study area is for tarsier locomotion.

The vegetation sampling for this study was carried out between the 17th and 27th of July 2005. A plot method was used. Rendigs et al (2003) also used plot methods to compare the forest structure with the distribution of mouse lemurs (*microcebus* spp.) 10m x 10m plots were set up on the north-south transects A-G at 0 m, 250 m, 750 m, 1250 m and 1750 m along the transects. Plots were placed at set distances along each transect so that both differences in habitat between each transect could be examined. The plots were placed at set distances along each transect so that trees were measured at points along the entire length of each transect. Each plot started 1 m in from the edge of the transect to diminish edge effects (Rendigs et al, 2003). All trees with a circumference at breast height (CBH at 1.3 m) of 3 cm or greater were measured, although dead trees were not included. CBH was later converted into diameter at breast height (DBH) using the formula:

$$DBH = CBH/\pi.$$

Basic measures of forest structure were calculated for each plot. These were:

- Total number of trees per plot.
- Average tree DBH per plot.

In line with Crompton and Andau's (1986) finding that 65% of the supports being used by tarsiers were under 3 cm in diameter and Niemitz's (1984) statement that *T. bancanus* showed a clear preference for supports of 4 cm or smaller, in this study trees with a DBH the same as or less than 4 cm were classed as trees of a DBH of preferred

tarsier locomotion. Therefore, in this study, a forest structure measure specific to the suitability of the habitat for tarsier locomotion was also calculated.

This was:

- Number of trees of preferred tarsier locomotion (i.e. trees of a DBH of between 4 cm and 1 cm).

The plots were grouped according to transect. To test for habitat differences a Kruskal-Wallis ANOVA was used to test for significant differences in the measures of forest structure:

- Total number of trees per plot.
- Average tree DBH per plot.
- Number of trees of preferred tarsier locomotion i.e. trees of a DBH of between 4 cm and 1 cm).

Statistical levels of significance were set at $p < 0.05$

Boubli et al (2004) also compared the total number of trees per plot and the average tree DBH per plot in their vegetation study in the Democratic Republic of Congo. They used ANOVA to test for differences between their “sample stations”. My study had a much smaller number of plots in each sample area and therefore the comparative non-parametric test to an ANOVA, a Kruskal-Wallis ANOVA was used in my study. Similarly, Rendigs et al (2003) also used a Kruskal-Wallis ANOVA to compare structural characteristics of microhabitats in their study looking into the

relationship between microhabitat structure and the distribution of mouse lemurs (*Microcebus* spp.) in North-western Madagascar.

Results.

Night Survey results.

A total of 50.850 km was walked, covering all transects twice (see Table 1 for more detailed information on the transects walked).

Four sightings of lorises occurred in the peat swamp study area, Setia Alam, yielding 9 individuals. No loris sightings occurred in the low interior forest. Two sightings of lorises, yielding 3 individuals occurred in the tall interior forest. The average perpendicular distance from the transect line to a loris was 12.6 m (range 6.6 – 28.3 m). No lorises were seen on the transect line. In two sighting events lorises were seen in groups of three. All lorises were seen at heights of 15 – 20 m with respect to the ground. The only activity when the lorises were first detected that was recorded was feeding behaviour, which was seen at two sightings. The species of plants lorises were located in are provided in Table 1. Information on the individual sightings can be found in Table 1.

Only one direct sighting of a tarsier occurred in the peat swamp study area, Setia Alam. The individual crossed the transect line at a height of 3 m. It was not possible to record any of the other information I had intended for this species. Three tarsier calls were heard during the transect walks. These were all weighted the same as direct sightings when calculating density estimates. No tarsiers were seen, or calls heard in the low interior forest or the tall interior forest. Information on the individual sightings can be found in Table 2.

				Sightings.		
	Transect	Transect length (in m)	Survey effort (in m)	No. animals in group	Group composition	Tree species (local name in brackets).
Peat Swamp Study Area	A	1950	3900	-	-	-
	B	2100	4200	-	-	-
	C	1925	3850	-	-	-
	E	2080	4160	-	-	-
	F	1950	3900	-	-	-
	G	1964	3928	1	Adult	<i>Combretocarpus rotundatus</i> (Tumi)
	0	1750	2750	2	Adult and infant	<i>Palaquium leiocarpum</i> (Hankang)
	0.4	1980	3670	3	All three lorises roughly the same size.	<i>Callophylum hosei</i> (Bintangor)
	1B	2000	2670			-
	0.8	1950	3650			-
	1A	1755	3510	3	One loris larger than other two.	<i>Syzygium cf. nigricans</i> (Jambu burung kecil)
	1.3	1800	3600			-
	1.6	1975	3950			-
2	1556	3112				
Low Interior	1	2000	2000	-	-	-
Tall Interior	1	3500	7000	2	2 Adults	Liana (unknown species)
				1	Adult	<i>Palaquium leiocarpum</i> (Hankang)

Table 1: Transects surveyed, survey effort for each transect and sighting information for *Nycticebus coucang menagensis* in the Sebangau National Park.

	Transect	Transect length (in m)	Survey effort (in m)	Sightings	
				No. animals in group	Method of detection and notes.
Peat Swamp Study Area	A	1950	3900	1	Heard tarsier "chick-chick-chick" call. Saw trees moving but could not locate animal.
	B	2100	4200	2	Heard two tarsiers "chick-chick-chick" calling 5 - 10m from the transect.
	C	1925	3850	1	Single tarsier crossed the transect line.
	E	2080	4160	-	-
	F	1950	3900	-	-
	G	1964	3928	-	-
	0	1750	2750	-	-
	0.4	1980	3670	-	-
	1B	2000	2670	-	-
	0.8	1950	3650	-	-
	1A	1755	3510	-	-
	1.3	1800	3600	-	-
	1.6	1975	3950	-	-
	2	1556	3112	1	Heard tarsier "chick-chick-chick" call.
Low Interior	1	2000	2000	-	-
Tall Interior	1	3500	7000	-	-
	2	2000	4000	-	-

Table 2: Transects surveyed, survey effort for each transect and sighting information for *Tarsius bancanus borneanus* in the Sebangau National Park.

Nycticebus coucang menagensis density estimate -

Following Greenwood (1996) a density estimate of 0.004 individuals/km² was found for the peat swamp forest study area.

Tarsius bancanus borneaus density estimate -

Following Greenwood (1996) a density estimate of 0.003 individuals/km² was found for the peat swamp forest area.

Habitat Characteristics.

A total of 6036 trees the same as or greater than 1cm DBH were present in the plot sample area of 350 m². This sample represents 17.5% of the 2 km² study area. Trees of a DBH of between 1 cm and 4 cm make up 66% of the trees in the study area. An average of 172 trees were measured in each 10m x 10m plot. There was an average of 114 trees per plot with a DBH of between 1 cm and 4 cm.

When the plots were grouped according to transect the following results were found:

The 7 transects did not differ significantly in the average tree DBH per plot ($X^2 = 5.924$, $df = 6$, $p = 0.432$) Transect B had the smallest average DBH (2.9 cm \pm 0.58), while transect D had the highest (3.88 cm \pm 0.35).

The 7 transects did not differ significantly in the number of trees per plot ($X^2 = 8.048$, $df = 6$, $p = 0.235$). Transect E had the smallest average number of trees per plot (138.2 \pm 28.3), while transect A had the highest (194.6 \pm 27.1).

The 7 transects did not differ significantly in the number of trees of a DBH 1cm-4cm per plot ($X^2 = 10.663$, $p = 0.100$, $df = 6$). Transect A had the highest average number of 1-4cm DBH trees per plot (156.4 ± 21.2), while transect E had the lowest (105.8 ± 20.3).

Discussion.

***Nycticebus coucang menagensis* densities.**

The density estimate of 0.004 individuals/km² calculated in this study suggests a very low abundance of *Nycticebus coucang menagensis* in the peat swamp of the Sebangau National Park. However, I think that there are a number of reasons why this density estimate may in fact not be a true reflection of the number of lorises to be found in this region. To explain why I think this to be the case, I will compare my methods and density estimate to those of other loris and nocturnal primate studies.

As previously mentioned, a number of other studies have provided slow loris density estimates. In comparison to these other estimates given for *Nycticebus* species, my density estimate is vastly lower. Wiens and Zitzmann (2003) provided a density estimate of 80 individuals/km² for unlogged primary forest and densities of more than 20 individuals/km² for logged dipterocarp forest, freshwater alluvial swamp forest and secondary padang savanna in Peninsula Malaysia. The 20 individuals/km² estimate seems the most suitable to compare to my density estimate because it is for a habitat type similar to that I was working in i.e. swamp forest and logged forest.

There are a number of differences between this study and my own which may help explain the differences in density estimates. Firstly, Wiens and Zitzmann (2003) carried out their study over four years, whereas my study took place over just two months. A longer-term study is more likely to overcome any biases in data collection. For example, the first eight days of my study yielded three sightings and seven lorises.

However, during the rest of the study (in the peat swamp area) only one more loris was sighted. My study began (due to the time constraints of the MSc course) at the end of the wet season. The wet season in Borneo runs from October until April, while the dry season runs from May until September. Habitat conditions, including seasonal variation can affect the detection function in line transect surveys (Ross and Reeve, 2003) and this may explain why I saw more lorises at the beginning of my study (when the dry season was just beginning) in comparison with the rest of my study. A longer-term study, which covers all of the seasons, removes any biases that may come with carrying out a study in only one seasonal period and therefore may show a better reflection of the long-term density of a species in an area.

The second difference between Wiens and Zitzmann's (2003) study and my own was that they worked out their density estimates using home range estimates whereas I used a line transect method to work out my density estimates. This different method means that the studies are less comparable because each set of methods comes with its own strengths and weaknesses that affect how accurate a density estimate is.

A study that did use a line transect method to calculate density estimates is Barrett's (1984) study on *Nycticebus coucang coucang*. The similar methods mean that the studies are more comparable. The density estimates he provides are 22.4 individuals/km² for unlogged forest and 15.7 individuals/km² for logged forest. These estimates are based on transect walks that covered a similar total distance to that of my survey - covering 59.7km. (in 82 census walks). Although Barrett's line transect surveys were part of a wider two year study it does not state over how long these census walks took place. Obviously, the habitat and the subspecies are different, with

Barrett's study taking place in Peninsular Malaysia on *Nycticebus coucang coucang*, whilst my study took place in Kalimantan on *Nycticebus coucang menagensis*.

Barrett (1981), in a paper based on the same study, provided a density estimate of 20 individuals/km² for one of his sites in Peninsular Malaysia. However, Barrett (1981) also mentions carrying out line transect surveys of a selectively logged site (Pasoh) which yielded just one sighting in 74 repeat census walks (although the total distance walked is unspecified) carried out over the course of a minimum of one year. This suggests a very low density at this site (although repeat census walks rather than walking different transects may bias the sample area). It is possible that even in the overall range of *Nycticebus coucang* (both sub species *N. c. coucang* and *N. c. menagensis*) there are areas more suitable and therefore with higher densities and areas less suitable and therefore with lower densities for slow lorises. Therefore, it is possible that the area of peat swamp forest sampled in my study is not optimal habitat for slow lorises and therefore there is a very low density there, but in other areas of more optimal habitat there may be higher densities.

Other researchers also suggest that there may be differences in densities due to differing habitat types for slow lorises. Johns (1986) looked at the effects of selective logging on the behavioural ecology of a number of West Malaysian primates and found that *N. coucang coucang* was seen less frequently in active logging areas but reappeared once logging had ceased however, they collected insufficient data to work out any changes in ranging patterns following logging and didn't provide any density estimates to show how less frequently slow lorises occurred in logging areas.

In a survey of the Javan slow loris, *Nycticebus javanicus*, walking 2 km twice each night for three weeks in Gudung Gede National Park in central Java only two lorises were seen (Gursky, pers. comm.). This suggests that there are areas of low density for this species of slow loris, or that the methodology used is not suitable for surveying lorises (see the section Problems with Methodology for further discussion of the suitability of line transects for surveys of slow lorises).

One study that does provide loris densities close to those found in this survey is that of Radhakrishna et al (2004) who found densities for *Nycticebus bengalensis* of between 0.03 – 0.33 individuals/ km² in four forest sites in Northeast India. However, there were a number of methodological issues with this study that are likely to have affected the densities of lorises seen. For example, the studies carried out were only partial night surveys and they were accompanied in the forest by 2-8 armed guards at all times. It is likely that having this many people in the forest at one time caused the lorises on the transect line to flee or hide before they could be detected. Therefore I do not think this study is comparable with my own.

Even though my sample size is small there were a few interesting things that came from my data, other than a density estimate, that should be brought to attention.

Group Size.

The conditions when studying animals at night are not optimal for observation. This, along with some nocturnal species showing cryptic behaviour means that the study of interactions, relationships and levels of sociality can be difficult to research (Sterling and Richards, 1995). Previous research into slow loris social systems by Wiens and

Zitzmann (2003) suggested that spatial groups of slow lorises consist of an adult pair and its own offspring. A spatial group of lorises was defined by Wiens and Zitzmann (2003) as “a set of individuals which all shared at least parts of their home ranges amongst each other.” Elliot and Elliot (1968) suggested a more polygynous mating system because they observed a group of six slow lorises (likely to be *N. coucang*); five males in pursuit of one female (showing reproductive behaviour).

Of the six loris sightings I recorded during the night survey walks in the Sebangau region (both peat swamp forest and tall interior forest), three of the sightings were of multiple lorises (see Table 1). Two groups of three lorises were seen in the peat swamp forest and one group of two lorises was seen in the tall interior forest. In one group of three lorises there was no discernable difference in body size between the three lorises. In the other group of three lorises sighted one loris was larger than the other two (Although this was only done by eye because the lorises were sighted at heights between 15 and 20 metres therefore I was not able to catch them and measure actual length or weight).

Of course, it is important to point out that even though three sightings were of multiple lorises, two sightings were of single individuals, and one sighting was of an adult with an infant. This means that on just as many occasions “solitary” lorises were seen as lorises in groups. Interestingly, the sighting of a group of two lorises that occurred in the tall interior forest occurred on the same night and 50 m away from another sighting of a lone loris. Wiens and Zitzmann (2003) defined “alone” as being >20m from any conspecific. However Charles-Dominique (1977) pottos can smell each other 50m away. I think that since the three lorises were located in close

proximity to each other it is possible that they were part of the same group, or at least part of the same “spatial group.”

In my study I was unable to sex the individual lorises seen due to the height of sighting (15-20 m in all cases), but the lorises showed no sexual or aggressive behaviour towards one another, as seen by Elliot and Elliot (1968). Still, the fact that multiple lorises were seen together (or in reasonably close proximity to one another) seems to agree with Wiens and Zitzmann (2003) and point to at least some degree of sociality in the slow lorises of the Sebangau National Park.

Activity at the time of detection.

The two groups of three lorises sighted were seen feeding at the time of detection. On both occasions all three lorises were seen feeding simultaneously in the same tree. On the first occasion the tree species was *Callophyllum hosei* (local name Bintangor). On the second occasion the tree species was *Syzygium cf. nigricans* (local name Jambu burung kecil).

Barrett (1984) suggested that *N. coucang coucang* has a diet of mainly fruit. This agrees with my data, although my data is from an incredibly small sample size. However, Wiens (2002) looked into slow loris diet using direct observations of feeding and analysis of faeces. He found that the slow loris (again, *N. coucang coucang*) diet is made up of plant saps, plant gums, floral nectar and flowers, fruits and arthropods, with the most feeding time spent on phloem sap, nectar or nectar-producing parts. It is likely that in my study the lorises were only seen feeding on fruit because this occurred high up in the canopy where it was easy to see the lorises.

Similarly, these observations were only activity on encounter data and so are not representative of the slow lorises feeding patterns in the Sebangau National Park.

There may, however, be subspecies differences in diet. Ravosa (1998) looked at differences in the skull and body size of different subspecies of *Nycticebus coucang* and suggested (also citing Kay, 1975) that larger bodied subspecies such as *N. c. bengalensis* (now classed as a species in its own right, by Brandon-Jones et al, 2004) may be more herbivorous, while smaller bodied subspecies such as *N. c. menagensis* may be more insectivorous. Although I did not see any insectivory during my study, this research into sub specific differences in skull and body size does suggest that the different subspecies may have different diets and therefore more work is required on the diet of *N. c. menagensis* in the Sebangau National Park to further investigate this possibility.

***Tarsius bancanus borneanus* densities.**

My tarsier density estimate is a very rough estimate, considering only one sighting was recorded and the rest of the density estimate is based on calls. Still, it is worth comparing it with other density estimates for *T. bancanus*, as well as density estimates of other tarsier species. There are very few *T. bancanus* population density estimates available in the current literature to compare to the one calculated in this study.

No other tarsier densities have been calculated using line transect methodology. Instead, Niemitz (1979) estimated the population density of *T. bancanus* based on a number of factors. He deduced that because *T. bancanus* lives in pairs (possibly with an infant or juvenile offspring), in home ranges of 9000 m²- 16000 m² (based on trapping records) then they have a population density of 80 individuals/km². There are a number of issues with the estimate. Firstly, a number of other researchers (for example Fogden, 1974; Crompton and Andau, 1986) suggest that *T. bancanus* has a noyau social system, rather than a monogamous social system and this is likely to effect home range size. Secondly, Niemitz himself points out that his density estimate was based on the assumption that tarsiers are spread throughout that habitat. He does point out that this assumption may not be true and therefore a smaller estimate would be more accurate. However, my habitat suitability study for the Setia Alam study area suggests that, at least for the factor of suitability for tarsier locomotion there is no significant difference throughout the habitat (discussed further in the habitat characteristics section of this discussion). Even so, I doubt when he suggested that a smaller density estimate would be more accurate that he meant a density estimate as small as the one calculated for my study.

Crompton and Andau (1986) did provide a smaller density estimate for *T. bancanus*. They estimated, using minimum home range (based on follows rather than trapping records) and Niemitz's (1984) methods of calculation, a population density of 14-20 individuals/km². Although this is a smaller estimate in comparison to Niemitz's estimation it is still much larger than my own density estimate. This is likely to be because of the differing methods of calculation. They suggest that population density estimates should be based on systematic close following of individuals rather than trapping records.

Densities for other tarsier species have been estimated at much higher numbers than the existing estimates for the Bornean tarsier. Gursky (1998) looked at two different Sulawesi species of tarsier and found average densities of 156 individuals/km² for *T. spectrum* and 129 individuals/km² for *T. diana*. However, when she looked into densities in different forest habitats a lower density of 22 individuals/km² was found for *T. diana* in primary forest habitat. This density figure is closer to some of the density estimates given for *T. bancanus* by other researchers, although it is still vastly larger than my own estimate.

There are a number of reasons why the density estimates for *T. spectrum* and *T. diana* are very different from the estimates for *T. bancanus*, and very different from my own estimate. The first reason that needs exploring is the type of methodology used to calculate the density estimates. Gursky (1998) used a modified form of fixed-point count and quadrat census methods to calculate her density estimates, whereas I used line transect sampling. There were a number of issues to do with the line transect methods (which will be discussed further in the Problems with Methodology

section of the Discussion), however Gursky's methods seem more robust because actual tarsiers were located and seen.

The second reason that needs exploring is the differing social systems of the different tarsier species. *T. spectrum* lives in small groups of 2-6 individuals (Gursky, 1998), whereas *T. bancanus* shows a noyau system with the home range of a male overlapping with the home range of one or more females (Fogden, 1974; Crompton and Andau, 1986). This difference in social system could be one of the reasons behind the difference in the population density of the two different tarsier species. A tarsier species with the same social system as *T. bancanus* is the Philippine tarsier, *Tarsius syrichta*. *T. syrichta* has a smaller home range size than *T. bancanus*, but at present no density estimates have been given for this species. It would be interesting to see whether this similar social system means the two species show similar densities.

Another reason why my density estimate is lower than other density estimates for *T. bancanus* may be the type of habitat the study occurred in. Crompton and Andau (1986), and Niemitz (1984) studies took place in unlogged forest, whereas the Sebangau peat swamp study area was selectively logged for thirty years until 1996. When different habitat types were compared in the tarsier species, Dian's tarsier, *T. dianae*, the smallest density of groups (5.6 groups/10ha) was found in selectively logged forest in comparison to three other forest types. Therefore, since the Sebangau was selectively logged up until recently, there may be a lower density of *T. bancanus* here in comparison to unlogged habitats.

Tarsier vocalisations.

According to Niemitz (1979), *T. bancanus* are not heard calling often in the wild. He goes on to say that when calls are heard they are usually only single whistles or short phrases. The call most often heard in this study was the “chick-chick-chick” call described by Crompton and Andau (1987). They think this call may indicate disturbance, which seems reasonable in that I was searching for unhabituated animals. It may also be that this call, rather than the “whistle of unknown motivational association” or “tsit-tsit-tsit call” was more obvious. Apart from information from Crompton and Andau (1987) and Niemitz (1979) we don’t know that much about *T. bancanus* calling, including calling rate etc. However, since all the calls heard seemed to be “disturbance calls” it suggests that the tarsiers were close enough to the transect to be disturbed.

During my study I heard tarsiers more often than I saw them. This suggests that future studies could focus on working out densities from calls rather than sightings. Indeed, in Sulawesi, where a number of tarsier species can be found (*T. spectrum*, *T. pumilus*, *T. diana*), densities are calculated, and animals located from their calls, which occur at dawn (Gursky, 1998; Gursky, 2000; Merker and Muhlenberg, 2000; Merker and Muhlenberg, 2005). However, line transect surveys during the second half of the night (i.e. from the middle of the night until dawn) did not yield any calls or sightings. Admittedly, due to the time constraints of the study this is not conclusive evidence that *T. bancanus* does not have an increased period of calling at dawn, although Crompton and Andau (1987) also state that there is no increase in calling activity at this time. This does mean that the Gursky (1998) method of

working out tarsier densities used in Sulawesi is not applicable to the Bornean tarsier species.

Habitat Characteristics.

Assuming that Niemitz (1985) and Crompton and Andau (1986) are correct in their measurements of tree DBH for the preferred supports used by *T. bancanus*, then Setia Alam field station, with trees of a DBH of between 1 cm and 4 cm making up 66% of the trees in the study area, is very suitable habitat for tarsier locomotion. Also, because no significant difference was found between the transects in the number of trees per plot or the number of trees between 1 cm and 4 cm DBH, this microhabitat variable seems to be high across the whole study area. Since only one tarsier was seen during the night surveys it was not possible to measure the DBH of the supports used to see whether there was actually a preference for supports of certain sizes. However it can be inferred that the peat swamp study area in the Sabangau region is made up of habitat suitable for tarsier locomotion.

A study that was able to compare tarsier densities with the availability of plant supports was carried out by Merker (2003, cited in Merker et al, 2005). The study found that in areas with high densities of Dian's tarsier, *Tarsius diana*, there was also a high availability of plant supports for tarsier locomotion. These areas also happened to be slightly or moderately disturbed (by human activity) habitats. In this way, the high number of suitable plant supports for tarsier locomotion in Setia Alam may be related to the fact the area was selectively logged for thirty years. Niemitz (1979) states that population densities of *tarsius bancanus* are highest in areas of secondary vegetation and a factor causing this may be the higher number of suitable plant supports for tarsier locomotion.

The forest habitat studied by Crompton and Andau (1986) differs from that of my study site because trees of a diameter 3-4 cm accounted for only 8.6% of the trees present. They do state that they think their study site and that of Niemitz (1985) are not very different in habitat structure. It seems that the peat swamp of the Sebangau does have a different habitat structure to both of these other study sites since trees 4 cm and less make up 66% of the trees in the study area. On this, admittedly very basic measure of habitat suitability for *T. bancanus* it does seem that the peat swamp study area is a suitable habitat, for tarsier locomotion at least. Of course, this does not take into account other requirements such as food availability (tarsiers are carnivorous, living on a diet of arthropods, birds, bats, snakes, Niemitz, 1979), or the presence of sleeping sites. Similarly, without good methods of measuring the density of tarsiers in this region it is not possible at this time to see if and how this habitat suitability is affecting tarsier distribution.

Problems with the Methodology.

There are a number of problems of and limitations to using line transects to estimate densities of nocturnal mammals (Duckworth, 1998). Barrett (1981) discusses some of the problems with night census walks. He points out that because slow lorises are located by their eyeshine, if they do not have their eyes open, are in thick foliage or are not looking at the torch beam then the researcher carrying out the census walk will not detect them. He also points out that because of their small body size and “cryptic mode of locomotion” (quadrapedal slow climbing) they did not give sufficient clues (e.g. in the movement of foliage or noise), which, in other species can be used to help locate/detect animals. Similarly, Duckworth (1998) points out that nocturnal animals can even be missed in the open area. He provides the example of a slow loris (*N. coucang* but subspecies is not mentioned) that was observed in a leafless tree for 55 minutes but could not be seen for minutes at a time because it was not looking at the torch. He goes on to state that a passing observer “could have easily overlooked it.”

This all means that even animals on the transect line may be missed. Detecting all individuals on the transect line is an assumption of most line transect methodology (for example Buckland et al, 1993) and if this assumption is not held then any density estimates calculated are likely to not be accurate.

There were a number of other problems with the methodology of this study. As previously mentioned in the Methods section, I had intended to use red light to locate the lorises and tarsiers but due to the lack of penetration of this light into the forest undergrowth I ended up using white light in my surveys. However, the assumption of line transect surveys is that all individuals on the line are detected (Buckland et al,

1993), therefore even the minimal light given off by red light filters should pick up slow loris eyeshine. Using red light that is unable to penetrate forest undergrowth is unlikely to successfully locate *T. bancanus*, a species that does not have eyeshine and is often found in the forest undergrowth (Crompton and Andau, 1986). This does suggest that, had my study been on only *N. c. menagensis* I could have used red light, although the use of white light did not seem to affect the behaviour of the lorises that were encountered in my nocturnal survey. Encountered lorises did not flee, but remained where they were (and when feeding continued to feed), even when myself or my assistant went to the base of the tree to measure the distance from the animal to the transect. Indeed, Williamson and Feistner (2003) state that most nocturnal primates continue doing the activity they were doing after noticing an observer's presence. Therefore the use of white light did not seem to adversely affect my ability to detect slow lorises.

A major issue with using line transects to calculate *T. bancanus* population densities is that they lack eye shine. In the dense vegetation of the peat swamp forest I found that, apart from one direct sighting, it was more often the case that tarsiers were heard but could not be located. A low precision in transect sampling has also been found for another primate species that is partly nocturnal and has no tapetum lucidum. Muller et al (2000) found that in multiple species line transects in Madagascar, the precision of transect sampling for a cathemeral species of lemur, *Eulemur mongoz*, was low because its lack of tapetum lucidum made detection at night more difficult than that of species possessing a tapetum lucidum. However, they do also point out that more replicates were needed for all strictly nocturnal species (even those with a tapetum

lucidum) because the light conditions and their cryptic behaviour made them generally more difficult to detect than diurnal species.

There may be some effect of using pre-existing trails to carry out the transect walks on in the detection of *T. bancanus*. Merker and Muhlenberg (2000) looked at the abundance of Dian's tarsier, *Tarsius diana*e in habitats of different levels of human disturbance. They found a lower abundance of tarsiers in slightly disturbed habitats even though resources were plentiful. They suggested that a possible reason for this lower abundance is the high susceptibility of tarsiers to "visual and acoustic disturbance in their environment." The trails at Setia Alam are used on a very regular basis. It may be that because the trails are "disturbed habitat" the tarsiers have moved away from them. Possibly in the future, new recce transects could be cut from the pre-existing transects to look for tarsiers in less "human disturbed" areas.

All of these problems with the methodology seem to suggest that line transects surveys may not be the best method to calculate density estimates for *T. bancanus* or *N. coucang menagensis*. Still, there is a need for density estimates for both these data deficient species to be calculated. I think that until methods which are better suited to surveying both species are found, line transects should still be used for *N. c. menagensis* surveys, which overall showed less problems than using line transect surveys for *T. bancanus*. Using the information from these problems I have provided a number of further study options for both study species.

Future studies – tarsiers.

It seems that line transect methods are not the most successful way to calculate *T. bancanus* densities, therefore in the future, other methods will need to be used to attempt to work out population densities. One method that could be used is mark-recapture methods, using mist or harp nets to capture the tarsiers. Future studies could use mist netting and mark-recapture methods (Fogden, 1974 ; Crompton and Andau, 1986 ; Gursky, 2000). Issues that need to be addressed before any mist netting is carried out are that Gursky (2000) points out that spectral tarsiers learn to avoid nets, Merker et al (2005) suggests that nets need to be monitored at all times because tarsiers can escape from mist nets and Crompton and Andau (1987) state that population densities for *T. bancanus* should not be calculated from trapping records alone. But, for a data deficient species it may be more productive to at least establish presence or absence through trapping.

Future studies – lorises.

During the write-up of this study I was put in touch with a group of researchers from the Centre for Biodiversity and Conservation Studies at the University of Indonesia (CBCS UI) who are proposing a survey of the Javan slow loris, *Nycticebus javanicus*, in Gunung Gede Pangrango National Park, Java. As has been discussed in the problems with methodology section, there were a number of issues with the methodology that only became apparent once I had begun my study. Information about problems such as these is very useful to others beginning projects because it means they can try and iron out these problems from their own project. For this reason, I began a correspondence with this group of researchers and passed on what I

hope are useful comments and information to help make their project successful. A copy of this correspondence, can be found in the appendix.

Future studies - Habitat characteristics.

Further study of microhabitats could yield more information on the suitability of microhabitats in the Sebangau National Park for *T. bancanus* and *N. coucang menagensis*. There are a number of other habitat characteristics that could be compared in different parts of the study area. For example, the presence/absence of and number of suitable sleeping sites in the different plots could be considered for both *T. bancanus* and *N. coucang menagensis*. Nekaris (2005) has done this for the red slender loris (*Loris tardigradus tardigradus*) in Sri Lanka, while Merker and Muhlenberg (2000) used sleeping trees as a measure of habitat quality and classed habitats that had a large distance between tarsier sleeping trees as lower in quality for *Tarsius diana*. However, until accurate density estimates for both species can be calculated it will not be possible to look at how either species is actually using the different habitats in the Sebangau National Park.

Conclusion and Summary.

The results of this study do not successfully provide population density estimates for either *Tarsius bancanus borneanus* and *Nycticebus coucang menagensis*. While the population density estimate for *N. c. menagensis* calculated in this study was found to be lower than density estimates for other *Nycticebus* species and subspecies it is likely that this is primarily due to problems with the methodology rather than being a true reflection of low densities in the peat swamp study area of the Sebangau National Park. The sightings of groups of lorises points to some degree of sociality in *N. c. menagensis*, although further study is still required to confirm whether *Nycticebus c. menagensis* has a monogamous social system, as Wiens and Zitzmann (2003) suggest for *N. c. coucang*. *N. c. menagensis* was seen to be feeding on fruit on two occasions during this study. As with slow loris social systems, further work is also required on the diet of *N. c. menagensis*.

The population density estimate calculated in this study for *T. bancanus* was also found to be lower than density estimates calculated by others. Again, this is likely to be due to problems with the methodology first and foremost, rather than an extremely low density of *T. bancanus* in the study area. *T. bancanus* was located primarily through its calls. At present not much is known about the calling habits of *T. bancanus* therefore further work is needed into the vocalisations of this tarsier species.

The habitat characteristics study found no significant difference between the transects in the forest structure variables of number of trees per plot, average tree DBH per plot, and number of trees of a preferred DBH for tarsier locomotion. Since a large

number of trees of a preferred DBH for tarsier locomotion was found in the study area it can be inferred that the peat swamp study area of the Sebangau National Park is suitable habitat for *T. bancanus* locomotion, although further work is necessary to look at the density of tarsiers in this habitat and whether they do prefer supports of certain sizes.

Longer studies, using line transects and other survey methods to complement the line transects are likely to provide a more realistic density estimate for both species. This is very much necessary due to the data deficient status of both *T. bancanus* and *N. c. menagensis*.

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Appendix.

Correspondence between Grace Blackham and Jarot Arisona regarding a research proposal for a Survey of the Javan Slow Loris (*Nycticebus javanicus*) in Gunung Gede Pangrango National Park, Java, Indonesia.

