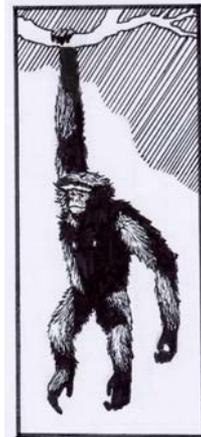# Survey of *Hylobates agilis albibarbis* in Unprotected Primary Peat Swamp Forest: Sebangau Catchment Area, Central Kalimantan.

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Research grant: The Orangutan Foundation

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Abstract

Virtually no data are available on gibbons that inhabit peat swamp forest. The aim of this study was to survey a population of *Hylobates agilis albibarbis* at Setia Alam Field Station. Setia Alam is located within the Sebangau Ecosystem, an area of over seven thousand square kilometres of unprotected primary peat swamp forest. The study was conducted from 28 June to 27 July 2004 using auditory sampling methods. Five sample areas were selected and each was surveyed for four consecutive days by three teams of researchers stationed a measured distance apart at designated listening posts. Researchers recorded compass bearings of, and estimated distances to singing groups. Nineteen groups were located. Population density estimates yielded the following results: 2.2 groups per square kilometre or 7.4 individuals per square kilometre. Sightings occurring either at the listening posts or obtained by tracking in on calling groups yielded a mean group size of 3.4 individuals. Extrapolation of results indicates a gibbon population in the region of 5700 individuals within one of the three major habitat subtypes: mixed swamp forest. Anthropogenic disturbance continues to threaten the fauna of the Sebangau region. It is hoped that these results will contribute to ongoing efforts to obtain protected status for the Sebangau region.

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List of Abbreviations

CIMTROP   Centre for International Co-operation in Management of

                   Tropical Peatland

GPS   Global Positioning System

ICDP   Integrated Conservation and Development Project

IUCN   The World Conservation Union

LAHG   Laboratorium Alam Hutan Gambut (Natural Laboratory (for

                   the Study) of Peat Swamp Forest))

LPF   Low Pole Forest

MSF   Mixed Swamp Forest

NGO   Non-Governmental Organisation

OUTROP   Orangutan Tropical Peatland Project

SSC   Species Survival Commission

TIF   Tall Interior Forest

WWF   World Wildlife Fund

Chapter 1 - Introduction

1.1 Gibbon Density in Peat Swamp Forest

This dissertation describes a population density survey of *Hylobates agilis albibarbis*, the Bornean agile gibbon conducted within the Sebangau Catchment Area from June to August 2004. Density estimates were obtained through the use of auditory sampling methods. The Sebangau region is an area of unprotected, primary peat swamp forest in Central Kalimantan, Borneo. This work will complement existing work in the area, which has focused on the wild Bornean orang-utan (*Pongo pygmaeus*) population.

The ability to survey primate populations is a vital conservation tool, especially for assessing populations at the initial phase (National Research Council, 1981; Brockelman and Ali, 1987; Sutherland, 2002). Primates that occur at low densities are of particular conservation concern, but low densities and cryptic behaviours make some primates difficult to survey (Sutherland, 2000). Although gibbons have formed the focus of many behavioural and ecological studies (e.g. Gittins, 1982; Chivers, 1984; Raemaekers and Raemaekers, 1985; Palombit, 1994; Reichard and Sommer, 1997; McConkey, 2000; McConkey *et al*., 2002; McConkey *et al*., 2003), limited data are available in terms of their population and demographic trends (Mitani, 1990; O'Brien *et al*., 2003; O'Brien *et al*., 2004). Both the media and the scientific world tend to overlook the conservation status of gibbons (Geissmann, 2002-2003a). However, it is worth noting that the Eastern black crested gibbon is listed among the 'Top 25 Most Endangered Primates' (IUCN/SSC Primate Specialist Group). Gibbon range use and size has been documented, but with conflicting results (Gittins, 1980; McConkey *et al*., 2002). In fact, gibbon range size and densities can vary as much as fivefold between study sites and, at present, no clear explanation for this has been established (Leighton, 1987).

Brandon-Jones *et al*. (2004), state that conservation measures need to be implemented for as many Asian primate subspecies as possible. *Hylobates agilis albibarbis* is IUCN listed as Lower Risk: NT (Eudey, 2000). In 2001, Groves (2001) isolated it as a separate species, but it is more commonly recognised as a subspecies (Marshall and Sugardjito, 1986; Geissmann, 2000; Brandon-Jones *et al.*, 2004). This investigation is one of only a few attempts to survey gibbons in peat swamp forest, and the first survey of this particular subspecies of gibbon. As a result, almost nothing is known about the density, behaviour and ranging patterns of gibbons that inhabit peat swamp forests.

Line transect surveys have not been advocated as reliable methods for surveying gibbon populations due to low visibility and unreliable behaviour upon detection (Brockelman and Srikosamatara, 1993; Nijman, 2004). Most gibbon species perform song vocalisations on most mornings from prominent locations; thus, auditory sampling methods have proved successful survey methods for this group of primates (Wilson and Johns, 1982; Johns, 1985; Brockelman and Ali, 1987; Mather, 1992; Brockelman and Srikosamatara, 1993; Nijman, 2004). Auditory sampling has long been employed for bird censuses (Bibby *et al*., 2000; Ross and Reeve, 2003). Call counts have also been used to generate indices of abundance for marine mammals such as humpback whales (*Megaptera novaeangliae*) and bearded seals (*Erignathus barbatus*) (Sutherland, 2002). Social calls made by bats (Order: Chiroptera) during flight have also been used as a census method to generate density estimates (Sutherland, 2002). These techniques are less common for primate surveys (National Research Council, 1981; Hanya *et al*., 2003) but have been employed to survey vocal primates, notably black howler monkeys (*Alouatta pigra*, (Estrada *et al*., 2002; Estrada *et al*., 2004)), spectral tarsiers (*Tarsius spectrum*, (Gursky, 1998)) and Japanese macaques (*Macaca fuscata*, (Hanya *et al*., 2003)). Specifically, auditory sampling has been used to survey a range of gibbon species including black

crested gibbons (*Hylobates concolor concolor*), lar gibbons (*Hylobates lar*), hoolock gibbons (*Hylobates hoolock*), pileated gibbons (*Hylobates pileatus*), Javan gibbons (*Hylobates moloch*), mountain agile gibbons (*Hylobates agilis agilis*) and siamangs (*Symphalangus syndactylus*) – (Haimoff *et al.*, 1986; Brockelman and Ali, 1987; Alfred and Sati, 1990; Brockelman and Srikosamatara, 1993; Nijman, 2004; O'Brien *et al.*, 2004 respectively).

Borneo harbours thirteen species of primate, eleven of which are found in Central Kalimantan (Mather, 1992) and six of which are endemic (Chivers, 1986). Kalimantan (Indonesian Borneo) is recognised as an area of high species richness and moderate endemism (MacKinnon *et al.*, 1997b) and yet all habitat types are under threat and have lost between 20-70% of their original cover (Barber, 1995). From a biodiversity perspective, loss of lowland rainforest in both Kalimantan and Sumatra is a particular cause for concern (Barber, 1995). The Sebangau Catchment Area is over 9000 square kilometres of peat covered landscape in Central Kalimantan (Morrogh-Bernard *et al.*, 2003). Peat swamp forests have received little attention in the past, as it was believed that these forests had low levels of biodiversity (Page *et al.*, 1997). In addition, they often occur in remote locations and present problems of access (Page *et al.*, 1997). However, more recent research indicates that peat swamp forests are rich in biodiversity (Morrogh-Bernard *et al.*, 2003). In addition, they perform a range of important environmental functions including carbon storage, water storage and supply, and climate regulation (Rieley *et al.*, 1997; MacKinnon *et al.*, 1997a; Morrogh-Bernard, 2003). Peat swamp forest covers extensive parts of Central Kalimantan, but only approximately 9 per cent is protected (MacKinnon *et al.*, 1997c). As Kalimantan has the largest remaining forested areas in Southeast Asia, its forests are of environmental importance on a global, rather than just, national scale (MacKinnon *et al.*, 1997a). Worryingly, these forests suffer from high levels

of anthropogenic activities (McLardy, 2002) and are of economic importance to the people of Kalimantan (MacKinnon *et al.*, 1997c). Peat swamp forests contain high densities of commercially valuable timber (Felton *et al.*, 2003), notably ramin (*Gonystylus bancanus*), which is endemic to peat swamps, and several merantis (*Shorea* sp.) species (Rieley *et al.*, 1997). Major threats to the survival of peat swamp forests include conversion to agriculture and illegal logging (Morrogh-Bernard *et al.*, 2003). Almost 20 per cent of Indonesia's peat swamp forests have been developed for agriculture (Rieley *et al.*, 1997). A secondary effect of logging is drainage. Illegal loggers cut extraction canals through the forest, which facilitate the movement of logs towards the river. This drains the ecosystem, destroys the hydrology and dries the peat making the area susceptible to fires (Morrogh-Bernard, 2003).

Located within the Sebangau Catchment Area is Setia Alam Field Station, run by the Centre for International Co-operation in Management of Tropical Peatland (CIMTROP) and the Orang-utan Tropical Peatland Project (OuTrop). Since 1996 research has focused on surveying the orang-utan population through the use of nest counts. A population size of 6000 individuals has been estimated (McLardy, 2002). The Sebangau is now recognised as being home to one of the largest surviving populations of wild orang-utans (McLardy, 2002; Morrogh-Bernard, 2003; Morrogh-Bernard *et al.*, 2003). Today, peat swamp forests support higher orang-utan population densities than any other habitat type (Felton *et al.*, 2003).

Data regarding the abundance of other primate species are lacking in the Sebangau region. Page *et al.* (1997) carried out biodiversity surveys in the Sebangau region, and determined that biodiversity was high, although population densities of many mammals, primates in particular, are lower in peat swamp forests when compared to other forest types (Page *et al.*, 1997; Rieley *et al.*, 1997). Agile gibbons were heard and sighted, but no density estimates were obtained. In Southeast Asia, the importance of peat swamp forests

in terms of conservation is likely to continue to increase, as, despite disturbance, they will become the only remaining areas of large, undeveloped, lowland forest (Page *et al*., 1997). The biodiversity surveys established the presence of a range of primate species in addition to the Bornean agile gibbon and the orang-utan (Page *et al*., 1997). These include: the common long-tailed macaque (*Macaca fascicularis fascicularis*), the pig-tailed macaque (*Macaca nemestrina*, possibly a geographically distinct population), the stripe-naped proboscis (*Nasalis larvatus larvatus*), the Bornean slow loris (*Nycticebus coucang menagensis*), the Bornean tarsier (*Tarsius bancanus borneanus*) and the maroon-red surili (*Presbytis rubicunda rubicunda*) (Brandon-Jones *et al*., 2004).

The results of this project will provide information for various local and international NGOs working to obtain protected status for the Sebangau region, including the World Wildlife Fund (WWF), CIMTROP and OuTrop (Husson, pers. comm.). In addition, advice is being provided to the relevant Indonesian authorities with a view to establishing an 'International Resource Centre', which will focus on research, sustainability and protection of peat swamp forests in the Sebangau region (Rieley *et al*., 1997).

1.2 Objectives of this Study

This study was conducted within the three square kilometre grid system at Setia Alam Field Station. Preliminary work by Cheyne identified the presence of five gibbon groups living within and around the grid system (Cheyne, pers. comm.). This project aimed to build on the work of Cheyne and the objectives were as follows:

1) To carry out a population density survey of *Hylobates agilis albibarbis* through the use of auditory sampling methods. Morning vocal duets signified the presence of a mated pair. Locations were determined through triangulation and then plotted on a map.

2) To determine average group size and age/class estimation of the gibbon groups through ground surveys; the triangulation points were used to aid group location. Physical and vocal characteristics were used to identify specific groups. Hopefully, this will facilitate future monitoring of demographic processes.

3) To document group home range size, through analysis of the triangulation points.

4) To compare results with information on gibbon home range size, group composition and population density from other research sites.

5) To discuss the implications of the results in terms of the conservation status of *Hylobates agilis albibarbis*.

Chapter 2 - Methods

2.1 Sebangau Catchment Area

The Sebangau Catchment Area is part of a large peat covered landscape in Central Kalimantan (see Fig. 2.1), which is bordered by the Katingan River to the west and Kahayan River to the east; the area is approximately 9,200 square kilometres (Morrogh-Bernard *et al*., 2003). Settlements and agricultural areas have been developed, particularly near to Palangkaraya (the provincial capital of Kalimantan). However 7,300 square kilometres is still covered by peat swamp forest (Morrogh-Bernard *et al*., 2003). The primary research site is the *Laboratorium Alam Hutan Gambut* (*LAHG; Natural Laboratory (for the Study) of Peat Swamp Forest*) a 500 square kilometre semi-protected area surrounding Setia Alam Field Station (Husson *et al*., 2004).
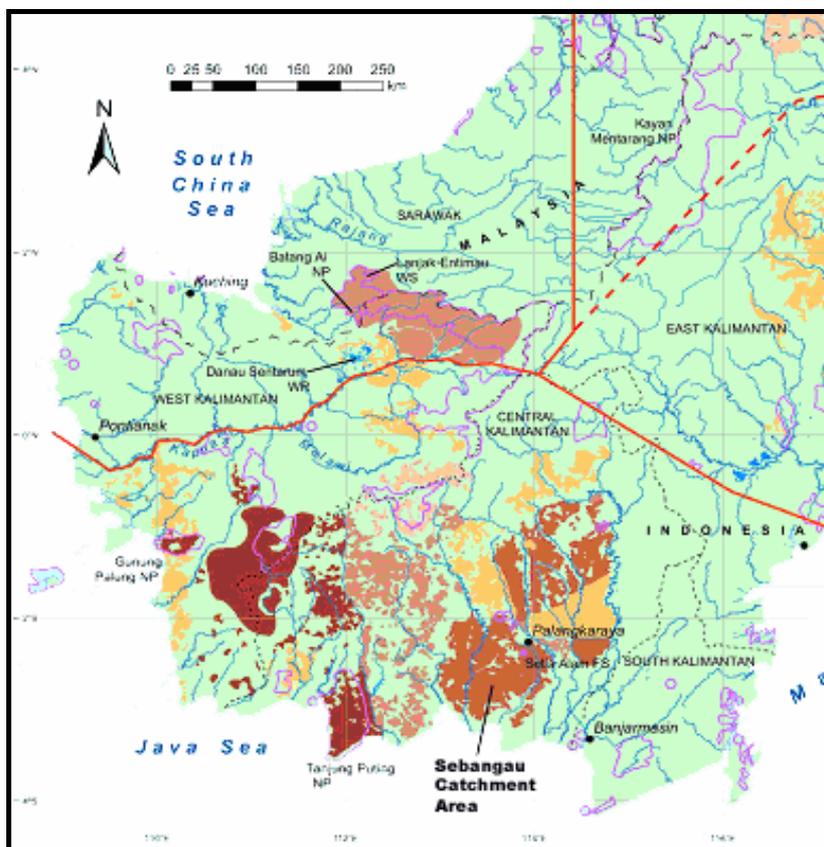
Figure 2.1   Map showing location of the Sebangau Ecosystem

Peat swamp forests typically encompass a sequence of forest sub-types, distributed from the perimeter to the centre of each swamp and changing from an outer high forest, to inner zones of lower canopy height (MacKinnon *et al.*, 1997c; Rieley *et al.*, 1997). Within the research area, three principal peat swamp forest sub-types have been identified. Mixed-swamp forest is located one to seven kilometres from the Sebangau river, is relatively high in diversity and has a canopy of approximately thirty-five metres; low pole forest is located eight to twelve kilometres from the river, is relatively low in diversity, is water logged all year round and has a canopy of approximately twenty metres; tall interior forest is located thirteen to twenty-three kilometres from the river, is relatively high in diversity and has a canopy of approximately forty-five metres (Morrogh-Bernard *et al*, 2003; Morrogh-Bernard, pers. comm.). The Sebangau region consists of rain-fed peat swamp forest; as distinct from mangrove (influenced by seawater) and river-fed freshwater swamp forest (MacKinnon *et al.*, 1997c).

2.2 Setia Alam Field Station

Setia Alam Field Station is situated in the northeast of the Sebangau Catchment Area, approximately twenty kilometres southwest of Palangkaraya. The field station is the research site and base camp for CIMTROP and OuTrop. Research on the ecology and biodiversity of peat swamp forest, and orang-utan density and distribution, has been ongoing since 1993. The site is proposed for an Integrated Conservation and Development Project (ICDP), (Smith, 2002). Setia Alam stands on the site of an old logging concession that practised selective logging for thirty years. When the concession ended in 1996, illegal loggers moved into the area (Husson, pers. comm.). The timber extraction railway still remains, and forms the eastern boundary of the grid system.

The grid system is three square kilometres and contains thirteen major transects, which are marked with flagging tape every twenty-five metres. The grid system is situated in mixed swamp forest, one of the three forest subtypes identified above. Data collection took place within a two square kilometre area within the grid system, although triangulation allowed researchers to survey gibbons beyond the grid system.

2.3 Study Species

There are twelve species of gibbon, comprising at least twenty nine taxa (Geissmann, 2002-2003b). Gibbons are found in Southeast Asia, Northwest India and Bangladesh (Reichard and Sommer, 1997). The agile gibbon (*Hylobates agilis*) is found in Borneo, Sumatra and the Malay Peninsula (Marsh, 1987). Three subspecies are recognised: the mountain agile gibbon (*Hylobates agilis agilis*), found in West Sumatra; the lowland agile gibbon (*Hylobates agilis unko*), found in East Sumatra and Peninsular Malaysia; and the Bornean agile gibbon (*Hylobates agilis albibarbis*), found in Indonesian Borneo (see Figure 2.2, courtesy of Geissmann, 2000). It must be noted however, that Brandon-Jones *et al.* (2004) only rate *H. a. unko* at the grade 'C' level of taxonomic confidence; and thus this classification requires further research. The other two subspecies are rated grade 'A', whose recognition the authors unreservedly endorse (Brandon-Jones *et al.,* 2004). *H. a. albibarbis* is endemic to Borneo, and is found in Southwest Kalimantan between the Kapuas and Barito rivers (Marshall and Sugardjito, 1986; Geissmann, 2000; Brandon-Jones *et al*., 2004). All three subspecies of agile gibbon are listed as IUCN Lower Risk: NT (Eudey, 2000).

Fig 2.2   Map showing distribution of *Hylobates agilis*

2.4 Gibbon behaviour

Gibbons are almost exclusively allopatric (Marsh, 1987), with the exception of *lar/agilis*

and siamangs (*Symphalangus syndactylus*) that occur sympatrically in Sumatra and

peninsular Malaysia (Leighton, 1987; Reichard; 2000; O'Brien *et al*., 2004). In addition, a

few small, natural hybrid zones exist in Thailand (*lar/pileatus*), Malaysia (*lar/agilis*) and

Kalimantan (*agilis/muelleri*) (Brockelman and Gittins, 1984; Marshall and Sugardjito,

1986; Mather, 1992; Reichard, 2000; McConkey, 2000; McConkey *et al*., 2002;

McConkey *et al*., 2003)

10

Gibbons are largely frugivorous, arboreal apes (Gittins and Raemaekers, 1980; Gittins, 1982; Gittins, 1983; McConkey *et al*., 2002). Gibbons are considered high quality seed dispersers (Gittins, 1982; McConkey *et al*., 2000; O'Brien *et al*., 2003); transporting seeds well away from the parent source (Gittins and Raemaekers, 1980) and thus play an important role in the regeneration of the forest (Das, 2002-2003).

Gibbons live in small groups of two to six individuals (Gittins and Raemaekers 1980; Leighton, 1987); average group size is four (Gittins and Raemaekers, 1982). Males and females reach sexual maturity around eight years of age and usually find a pair-mate by age ten (Gittins and Raemaekers, 1980; Leighton, 1987). A mated pair produces five to six offspring during their reproductive lifespan (Leighton, 1987). Mitani (1990) found a minimum interbirth interval of 3.2 years for *H a. albibarbis* at a study site in West Kalimantan. This is significantly higher than that of most monkeys and prosimians (Mitani, 1990).

It was traditionally thought that gibbons form monogamous pairings (Gittins and Raemaekers, 1980; Gittins, 1982; Leighton, 1987; Mitani, 1987; Mitani, 1990). However, the emergence of long-term studies has revealed that a degree of social flexibility exists, and that these pairings are rarely life long (Palombit, 1994; Reichard, 1995; Reichard and Sommer, 1997; Sommer and Reichard, 2000; Reichard; 2000).

Gibbons hold territories and home ranges (Gittins and Raemaekers, 1980; Leighton, 1987). Territories are thought to be exclusive (Gittins and Raemaekers, 1980; Reichard and Sommer, 1997), whereas home ranges overlap with other groups (Gittins and Raemaekers, 1980; Reichard and Sommer, 1997), especially in high density areas (Mitani, 1990) as suitable habitats are usually saturated, producing a pattern of closely interlocking home ranges (Gittins and Raemaekers, 1980; Leighton, 1987; Mitani, 1990; Reichard and Sommer, 1997).

2.5 Reconnaissance Visit

A reconnaissance visit was conducted from 18 March to 23 March 2004. During this period, I met with OuTrop project directors, Helen Morrogh-Bernard and Simon Husson, to discuss the logistics of my research. I also obtained maps of the grid system, and spent some time in the forest, familiarising myself with the transect system.

One of my objectives during this visit was to establish the location of listening posts for the auditory sampling method, as these should be prominent terrain features (Brockelman and Ali, 1987). The existence of pondoks (wooden huts used by local people who collect various resources from the forest) and tall wooden towers (used by local people to catch bats) was noted and their positions marked on a map. One of the pondoks was in fact used for the third sample period (see Section 2.10). This location was the furthest from base camp and was difficult to reach in darkness. Therefore, researchers spent four nights at the pondok (11 to 15 July), in order to be in position when the gibbons commenced calling. Transect junctions were used for the majority of listening posts. As these are marked with flagging tape they were easy to locate and facilitated the measuring of distances between posts.

2.6 Research Assistants

The research team comprised myself (principal investigator); an Indonesian field assistant, employed by OuTrop, and seven OuTrop research volunteers. On any given day, the research team involved six members, one Indonesian field assistant, four volunteers and myself. The six individuals were split into three teams of two. The large numbers of researchers involved in this project posed potential problems regarding consistency of data collection. Several steps were taken to avoid this. All field assistants were briefed on arrival at Setia Alam, and data collection protocols were drawn up and distributed to all

individuals involved (see appendices 1 and 2). Data collected on the 28, 29 and 30 June are not included in the analysis, as they were used to familiarise all team members with the data collection techniques required and to identify any problems. The Indonesian field assistant, one research volunteer and myself worked exclusively on this project and were the team leaders for each team. Other research volunteers were partly involved in this project, but were also engaged in other activities at the site. Watches were synchronised to the nearest second prior to departure from base camp each morning (Brockelman and Ali, 1987) and all teams were in continual contact through the use of hand held radios that were charged every night at base camp.

2.7 Triangulation

Auditory sampling methods were the principal techniques employed during this investigation. The techniques were selected for several reasons:

(1) line transects are not advocated as useful when surveying gibbons (Brockelman and Ali, 1987; Brockelman and Srikosamatara, 1993).

(2) Mapping of triangulated points is useful for territorial species (Sutherland, 2000) – although for territories that are held by a group, mean group size must be determined (see section 2.15), (Sutherland, 2000).

(3) Auditory sampling methods are useful techniques for surveying primates that have an extensive and regular vocal repertoire (Davies, 2002).

(4) Loud calls can be used to detect groups from greater distances than is possible with sightings (Davies, 2002), vital given the restricted research period.

In mountainous terrain, estimation of the listening area is simplified as ridges and valleys create natural boundaries regarding the distance that vocalisations can carry (Brockelman and Ali, 1987). With level or undulating terrain (as is typical of this study

area), how far groups can be heard cannot easily be determined from a topographic map (Brockelman and Ali, 1987). Therefore, triangulation was required: three teams of two researchers were stationed a measured distance apart (following Brockelman and Ali, 1987, who recommend a distance of between 300 – 600 metres for gibbon surveys, see Table 2.1).

Table 2.1   Distance between listening posts for each sample period

Sample Period	Distance between listening posts A & B	Distance between listening posts A & C	Distance between listening posts B & C
1	370 metres	450 metres	340 metres
2	450 metres	370 metres	345 metres
3	310 metres	435 metres	320 metres
4	380 metres	310 metres	360 metres
5	150 metres	270 metres	310 metres

For sample periods one to four, the listening posts were stationed between 310 metres and 450 metres apart. It was felt that the lower end of the recommended scale (300 to 600 metres) was appropriate for this study as gibbon calls do not carry as far in level forest (see below) and it was important that all researchers heard as many of the same groups as was possible. Sample period five proved to be an exception, as actually two of the distances between listening posts were under the recommended distance (less than 300 metres); 150 metres and 270 metres between post 5a and 5b and 5a and 5c respectively. This was due to the constraints of the grid system as transects 1.3 and 1A (where the fifth group of listening posts were located) are in closer proximity to each other than the other transects. However, this did not affect the effective listening area (defined as the area within which at least two of the three teams of researchers could clearly hear calling gibbon groups up to a kilometre away). The effective listening area was calculated per sample period (see Figure 2.3, p. 5 for example) and was between 2.9 and 3.0 square kilometres for each sample period.

Key to shaded areas:
Blue = proportion of effective listening area where researchers from all three posts could hear gibbon groups up to 1 km away
Green = proportion of effective listening area where researchers from two posts could hear gibbon groups up to 1 km away
Yellow = proportion of effective listening area where researchers from one post could hear gibbon groups up to 1 km away
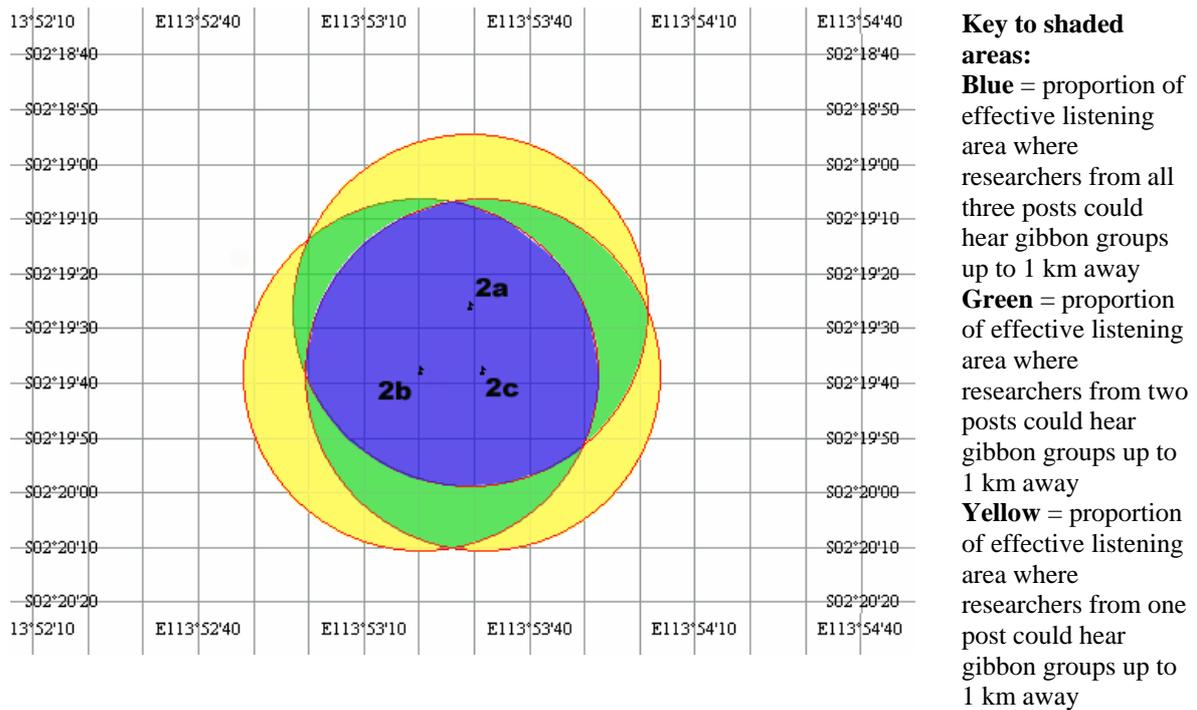
Fig. 2.3   Figure showing how the effective listening area was calculated, using the second sample period as an example.

As transects are marked every twenty-five metres, this was used to measure the distance between listening posts. This was confirmed by taking a GPS waypoint of each listening post. During data collection, researchers recorded the exact time, compass direction and estimated distance to all groups heard (see Appendix 3). A Silva Voyager 8040 compass with a sighting mechanism was used, as the sighting mechanism helps to take more accurate bearings (White and Edwards, 2000a). Lengths of song bouts were recorded using a stopwatch. A song bout refers to a bout of singing given by a mated pair (as defined by Gittins, 1984). The bout was deemed to have ended if the gibbons were silent for more than two minutes (Gittins, 1984). Subsequent singing was then recorded as a new bout. Synchronised bearings were recorded at intervals of three minutes. In other words, each team took a bearing and estimated the distance to each group that they could clearly hear calling, at intervals of three minutes. When the data were analysed, only bearings that were taken at the same time were mapped.

An effective listening radius of one kilometre was selected prior to data collection (Brockelman and Ali, 1987). Gibbons tend to sing from the highest treetops, which increases the distance that their songs carry (Gittins and Raemaekers, 1980; Gittins, 1983). Gibbons can be heard clearly over a distance of up to two kilometres depending on the terrain (Gittins and Raemaekers, 1980; Gittins, 1984; Leighton, 1987; Reichard and Sommer, 1997; O'Brien *et al*., 2004). Previous surveys of this nature selected a listening radius of two kilometres (O'Brien *et al*., 2004). However, as the forest at Setia Alam is dense and the terrain flat, one kilometre was selected as audibility of gibbon calls does not generally exceed one kilometre through level forest (Brockelman and Ali, 1987). Centres of group ranges that were mapped outside the effective listening radius were excluded from the analysis (Brockelman and Ali, 1987)

Five groups of listening posts were selected within the two square kilometre area: one pair in the centre of this area and the other four pairs in each of the four corners of the area. This allowed the whole of the area to be surveyed within the time constraints. Previous research shows that agile gibbons sing most frequently between 0600 and 1000, 65 per cent of calls occurred between 0600 and 0800 and only 4 per cent after 1000 (O'Brien *et al*., 2004). To ensure that all calls were heard and noted researchers were always in position by 0430, as calls of some gibbon taxa are known to occur before dawn (Gittins, 1984). Researchers remained at the listening post until 1000 or for thirty minutes after the last group was heard calling (Cheyne, pers. comm.). As researchers were at the listening posts for long periods of time, sightings were also recorded when they occurred.

2.8 Agile Gibbon Vocal Characteristics

The vocal characteristics of *Hylobates agilis albibarbis* are largely identical to the vocal characteristics of *Hylobates agilis* (Geissmann, 2000; Brandon-Jones *et al*., 2004). Several

hypotheses regarding the function of singing behaviour have been proposed, but its probable use as a spacing mechanism (to deter co-specifics from entering an occupied territory), has received the most support (Raemaekers and Raemaekers, 1985; Haimoff and Gittins, 1985).

Familiarisation with the vocal characteristics of the study species is vital for auditory sampling methods (Brockelman and Ali, 1987). All singing behaviour was recorded during the data collection, but only duets and group song bouts were used in the density analysis, as this indicates the presence of a mated pair (Brockelman and Ali, 1987). Solo calling males have to be eliminated since it is not possible to determine whether it is a dispersing individual or a resident of a group (O'Brien *et al*., 2004). A duet or dawn duet (Gittins, 1984) typically commences with the male, followed by the female, who joins in initially by giving phrases similar to the male and then starts giving great calls. Great calls have a general pattern of a level start (in pitch), a rising climax and then a step-wise descent (Gittins, 1984). In this sense, duets are easy to distinguish from other vocal behaviour (Brockelman and Ali, 1987), as they contain a 'coda' by the male and a great call by the female (Haimoff and Gittins, 1985). Moreover (with the exception of *Hylobates klossii* and *Hylobates moloch*) females of most gibbon species confine their singing behaviour to duet song bouts only (Geissmann, 2000). Duets commence usually just before, or just after dawn, peaking between the hours of 0600 and 0700 (Gittins, 1984).

Morning song bouts also involve vocal behaviour by the male, and great calls by the female, but often female adolescents 'practise' giving great calls with their mothers and other infants also sometimes take part (Gittins, 1984). These songs usually take place between 0700 and 0800, in tall emergent trees (Gittins, 1984). Sitting is the most common posture during singing, although some brachiating occurs during the climax of the female great call (Gittins, 1983; Gittins, 1984). Vocal behaviour was also used to aid group

identification, 'practising' adolescent or sub-adult females are easily distinguishable (Gittins, 1984; Cheyne, pers. comm.), subadult males often sing around dawn, with or without the adult male (Mitani, 1990) and adolescent gibbon singing behaviour is recognised as acoustically simpler and quieter than the adults (Mitani, 1990).

2.9 Group Encounters

Knowledge about group encounters is scarce (Reichard and Sommer, 1997), although conflict between neighbouring groups is known to be accompanied by vocal behaviour where the males give characteristic hoot sequences, which are unique to this context (Gittins, 1980; Gittins, 1984; Reichard and Sommer, 1997). Females also join in by giving great calls (Gittins, 1980; Gittins, 1984).

Encounters between groups usually take place when two groups become aware of each other's presence within distances of 100 to 150 metres (Reichard and Sommer, 1997). This is sometimes referred to as a territorial dispute (Gittins, 1983) as it is most commonly thought that group encounters reflect territorial defence (Gittins and Raemaekers, 1980; Gittins, 1980; Gittins, 1982; Gittins, 1983; Leighton, 1987; Mitani, 1987). However, other studies claim that, while this may be one function of group encounters, it is also an opportunity for individuals to pursue reproductive opportunities outside of their pair bond, referred to as extra-pair copulations (Reichard and Sommer, 1997). In other words, that pair living is combined with reproductive polygamy when the opportunity presents itself (Reichard, 2000). This links in with other recent research discussed earlier, indicating that the traditional view of gibbon monogamy is questionable and that various degrees of social flexibility exist (Palombit, 1994; Reichard and Sommer, 1997; Sommer and Reichard, 2000). As this issue remains unresolved, group encounters will be referred to as such and not territorial disputes for the remainder of this study.

2.10 Frequency of Calling

In order for loud calls to be used for sampling gibbon populations, the average frequency of calling and the variables that affect frequency must be studied in a population of known groups (Brockelman and Ali, 1987; Brockelman and Srikosamatara, 1993). Due to time constraints, it was not possible to carry out a preliminary study of this nature; thus, published data regarding the singing frequency of agile gibbons was used. O'Brien *et al*. (2004), found that the probability of agile gibbons calling on any given day was 0.42. This figure rose to more than or equal to 0.75 per three day period and more than or equal to 0.89 per four day period. For agile gibbons, the variance seems to stabilise by day four (O'Brien *et al*., 2004); thus, each listening post was surveyed for a period of four consecutive days during this study, with the exception of the second set of listening posts which was surveyed from the 6 –7 July and 9 – 10 July. Very heavy rain on the morning of the 8 July made data collection impossible.

Although there was not time to conduct a preliminary study, probability of calling rates were generated from this data after the research period. This was based on the number of groups located and the number of calls recorded for each group. This allowed two sets of density estimates to be generated and compared, based on a published correction factor for agile gibbons (O'Brien *et al*., 2004) and the correction factors generated by this data (see Section 2.14).

Listening posts 1a, 1b and 1c were surveyed from 1 July to 4 July 2004; 2a, 2b and 2c from 6 July to10 July 2004; 3a, 3b and 3c from 12 July to 15 July 2004; 4a, 4b and 4c from 19 July to 22 July 2004 and 5a, 5b and 5c from 24 July to 27 July 2004.

2.11 Weather

As mentioned previously, variables that potentially affect singing frequency must be considered in the analysis. One such variable is weather (Brockelman and Ali, 1987; Brockelman and Srikosamatara, 1993). Gibbons seldom sing when it is raining, and windy conditions have also been shown to affect singing frequency (Leighton, 1987; Brockelman and Ali, 1987; Brockelman and Srikosamatara, 1993). Bad weather days should be defined objectively (Brockelman and Ali, 1987) and potentially excluded from the analysis (Brockelman and Srikosamatara, 1993). Some researchers have demonstrated that weather had little effect on the daily number of calls per group (O'Brien *et al*., 2004), but it was felt that it was important to record the weather, even if only to exclude it as a variable. Thus, weather was recorded at ten-minute intervals while vocalisations occurred (see Appendix 4) (Brockelman and Srikosamatara, 1993; O'Brien *et al*., 2004). Following Brockelman and Srikosamatara (1993), weather was classified as clear, cloudy (<50%/>50%), rainy, calm, breezy (leaves rustling) or windy (boughs shaking). Temperature was noted daily, using a good quality max-min thermometer positioned near base camp at a height of 1.25 metres above ground level (Sutherland, 2000). Rainfall was also measured daily with a rainfall gauge (Brockelman and Srikosamatara, 1993). Temperature was measured at the same time each day, before the afternoon heat (White and Edwards, 2000b). Rainfall was recorded once in the morning and once in the evening.

2.12 Mapping

Daily triangulation points were marked on maps of the study area. At the end of each sampling period, these points were overlaid onto a single map. Sightings were also recorded on the maps. Map making equipment included a 360 degree protractor, graph paper, a ruler and a pencil (Davies, 2002). Data analysis took place between the hours of

1130 and 1700 on every day after data collection, for approximately two hours. All researchers were involved and this allowed researchers to begin to establish the number of groups present during the research period (Estrada *et al.*, 2004). Points mapped more than 500 metres apart are considered to be different groups (Brockelman and Ali, 1987; Brockelman and Srikosamatara, 1993; O'Brien *et al.*, 2004). This figure is based on the approximate diameter of a group's range and determines the maximum distance that agile gibbons might move between calls (O'Brien *et al.*, 2004). This seems appropriate for agile gibbons, which have been documented to call always from within the boundaries of their territory (Gittins, 1982). Home range size for gibbons has been documented to vary between seven and fifty-eight hectares (Gittins and Raemaekers, 1980; Gittins, 1980; Gittins, 1982; Leighton, 1987; Mitani, 1990; McConkey *et al.*, 2003). Assuming that home ranges are roughly circular, the range diameter would vary from fifty metres to 370 metres (O'Brien *et al.*, 2004). As previously mentioned, primate densities in peat swamp forests may be lower than in other forest types. For gibbons, this could also potentially mean larger ranges. The brief study by Cheyne at Setia Alam documented the existence of five gibbon groups residing within and around the grid system (Cheyne, pers. comm.), allowing a home range of sixty hectares. Even an exceptionally large home range of seventy hectares would have a diameter within 500 metres (472 metres). It was thus felt that 500 metres was a conservative separation for calling groups, which incorporated the possibility of larger home ranges for peat swamp forest gibbons and the ellipsoid nature of many home ranges (O'Brien *et al.*, 2004).

2.13 Ground Surveys

The main objective of the ground surveys was to locate the gibbon groups that had been mapped through triangulation. Searching for triangulated groups through ground surveys

has been successful during other auditory sampling surveys (Mitani, 1990; Estrada *et al*., 2002, Estrada *et al*., 2004). In addition, sightings of other primate species were also recorded. On days when triangulation was conducted, researchers also carried out ground surveys. These occurred between 1000 and 1500 hours. At an agreed time, the three groups of researchers left the listening posts and commenced ground surveys. Each team walked slowly on existing trails (one kilometre per hour, Ross and Reeve, 2003; Estrada *et al*., 2004). The last compass bearings on which calls were recorded were used as a way of trying to locate groups (Cheyne, pers. comm.). All teams tracked in on the same compass bearing/gibbon group. As the teams were coming from different directions and the gibbons are not habituated, it was decided that this would increase the chance of sightings. If a gibbon group was sighted, number of animals, age/class estimation and direction of travel was noted (see Appendix 5). Running simultaneously to this research at the same study site, a separate group of researchers used the line transect method to generate mammal densities. Preliminary results for the agile gibbon will be considered in the discussion, in comparison to the results generated by this study.

During the data collection trials and the early stages of data collection, no sightings occurred using the ground survey method. As sightings were vital to confirm group location and to calculate a mean group size, it was decided that researchers would attempt to track in on calling groups. Researchers decided that if a gibbon group was calling less than 300 metres away from a listening post, the team at that post would attempt to locate the group. As teams were in continual contact by radio, the team tracking would inform the other teams prior to departure. A compass bearing to the group in question was always taken prior to tracking. The other teams would continue recording compass bearings and the team tracking would resume this activity after the sighting had occurred. Ground

surveys continued to be carried out on an alternate day basis, to further test the effectiveness of this method.

2.14 Agile Gibbon Physical Characteristics

Hylobates agilis albibarbis is noted for its contrasting pelage – a dark chest and cap with black hands and feet. The adults exhibit a moderate degree of dichromatism: the females tend to have a light brow band whereas the males tend to have contrasting light cheeks – light brown, grey or white in colour (Geissmann, 2000).

When clear sightings of gibbons were made, age classes were assigned through reference to behavioural and physical characteristics of the animals. Following Mitani (1990), those still carried by their mothers during travel were classified as infants. Juveniles travelled independently and were recognised by their small size (less than half the size of the adults). Individuals more than one half the size of the adults but not yet fully grown were classified as adolescents. Subadults were similar in size to adults but not yet mated. Sex classes were not always clear. As with Geissmann, Mitani (1987) states that male agile gibbons have white beards and white tufts of hair around their genitalia, whereas the females lacked these features. Although these characteristics gave an indication of sex, females (indicated by the presence of ventral infants) with beards were sighted, and it was thus felt that this was not a reliable distinction. Thus, sex classes were only assigned to adults and sub-adults, and this was aided by vocal behaviour.

2.15 Data Analysis

The points plotted from each sample period were combined to produce one hand-drawn map. In addition, the location of all the listening posts and some of the gibbon sightings were recorded using a Garmin GPS12.

Population density estimates of *Hylobates agilis albibarbis* were then obtained by the use of the following four equations:

$$D = \frac{n}{E}$$ (Brockelman and Srikosamatara, 1993)

where: D = density

n = no. of groups heard per sample period

E = effective listening area.

An effective listening area was calculated for each sample period, defined as the area within which at least two of the three teams of researchers could clearly hear calling gibbon groups up to a kilometre away; i.e. the proportion of the circles that overlapped. The derived 'E' was divided by the number of groups heard within the corresponding sample period.

The second equation follows the same method but incorporates a correction factor:

$$D = \frac{n}{E} \times \frac{1}{p}$$

where: D = density

n = no. of groups heard per sample period

E = effective listening area

p = is the proportion of individuals expected to sing during one sample period.

Probability of calling based on published data for agile gibbons is 0.89 (O'Brien *et al.*, 2004: see Section 2.10). Probability of calling generated from this data negates the need for a correction factor because it was equal to 1.0 over a three-day period (see Appendix 7) and each post was sampled for four days. Thus the density estimate using the data from this study would be identical to the first method, which does not include a correction factor.

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A third density estimate was generated by referring to the visual representation of the results (see Fig. 3.1, p. 30) and estimating the percentage of each gibbon group home range located within the two square kilometre area (where listening posts were positioned).

$$D = \frac{n}{A}$$

where: D = density

n = no. of groups mapped within 2 km^2 area

A = 2 km^2 area encompassing the five sets of listening posts.

This equation incorporating the published correction factor is calculated by:

$$D = \frac{n}{A} \times \frac{1}{p}$$

where: D = density

n = no. of groups mapped within 2 km^2 area

A = 2 km^2 area encompassing the five sets of listening posts.

p = is the proportion of individuals expected to sing during one sample period

Mean group size was calculated through an analysis of all sightings recorded and was used to calculate an individual density for each of the above density equations. Mean start time, stop time and duration of song bouts was also analysed, as this information was recorded during triangulation.

To ascertain whether weather conditions had an effect on singing frequency, start times or song length, the following statistical tests were used: product-moment correlation coefficient for rain, Mann-Whitney U for temperature, and Chi-square for cloud cover and wind. The significance level was set at 0.05.

2.16 Assumptions and possible bias of the method

Two major assumptions are associated with this method. Firstly, that all duets represent a group (National Research Council, 1981; Haimoff *et al*., 1986). Johns (1985) takes this assumption a step further, claiming that the technique assumes that all sources of call represent social groups or in other words, that dispersing individuals do not call. This is incorrect. Dispersing individuals do call, particularly solitary males, but researchers must differentiate between calls and not include solo calls in the density analysis (Brockelman and Srikosamatara, 1993). The second assumption is that all groups call at least once during the period of the survey (National Research Council, 1981; Johns, 1985; Haimoff *et al*., 1986). An alternative is to try and calculate the percentage of groups that call within the sample period (Brockelman and Ali, 1987) and apply this figure as a correction factor in the data analysis (as explained above).

Other assumptions are that distances to calling groups are recorded accurately (Hanya *et al*., 2003) and that locations of animals are not influenced by observers (Hanya *et al*., 2003). The first of these can be solved by employing triangulation techniques (three teams of observers per sample area as opposed to one or two so that accurate estimation of distance is not relied upon). The second assumption will be considered in the discussion.

Bias may be associated with determination of the effective listening area (Brockelman and Ali, 1987). Bias may also be associated with the effect of density, environmental conditions and seasonal variation on singing frequency (Chivers and Raemaekers, 1980; Haimoff *et al*., 1986; Brockelman and Ali, 1987; Brockelman and Srikosamatara, 1993; Davies, 2002; Sutherland, 2002; O'Brien *et al*., 2004). Exactly what causes variation in singing frequency remains unexplained (Brockelman and Ali, 1987), but the bias is reduced by listening for at least two to three mornings at each site, which

has the effect of increasing the number of groups that sing (counted cumulatively) per sample period (Brockelman and Ali, 1987; Brockelman and Srikosamatara, 1993).

A final potential bias is the danger of double-counting groups (O'Brien *et al.*, 2004). Two steps can be taken to avoid this. First, only when centres of group ranges are mapped more than 500 metres apart are the groups considered separate (Brockelman and Ali, 1987; Brockelman and Srikosamatara; 1993; O'Brien *et al.*, 2004); although Haimoff *et al.* (1986) used a much smaller distance and distinguished between groups if they were sighted or heard over 100 metres away. Second, the employment of directional and acoustical information helps to differentiate between groups (Brockelman and Srikosamatara, 1993).

Chapter 3 – Results

3.1 Visual representation of results

Researchers recorded a total of 125 calls over a period of twenty days; indicating that some groups called more than once on any given day. Twenty-nine of these were solo calls; the remaining ninety-six were duets including the distinctive female great call. Solo calling was not used in the density analysis. Of the ninety-six duets, sixty-five produced two-point bearings, three-point bearings and triangulations. These were plotted on a map of the grid system to discover the number of groups and approximate territories of each group (see Fig 3.1, p. 30).

The position of all the listening posts are indicated, as is the old railway track that forms the eastern boundary of the grid system. A cross indicates three-point bearings; this was when the compass bearing from each team met at a perfect point. A star indicates two-point bearings; this was when the calling group was only heard by two of the three teams. A triangle indicates where three bearings come together to produce triangulation. This means that the gibbon group in question was calling from somewhere within the triangle. A circle indicates sightings. All bearings and sightings are marked with the time and date. A jagged line marks possible boundaries between groups, this is explained below (see Section 3.2). In total, nineteen groups were identified and are referred to as G1 – G19. Groups mapped more than 500 metres apart are considered separate groups. This figure corresponds to the maximum possible diameter of a group's home range; thus, centre of group ranges should be ≥ 500 metres apart (Brockelman and Srikosamatara, 1993). Due to the limited research period, there is insufficient data to analyse group range size. Instead, this was analysed through the density equation (see section 3.3). Thus, triangulation points mapped ≥ 500 metres apart are considered separate groups; points mapped less than 500

metres apart are assigned to groups based on other information collected, for example by establishing which other groups were singing during the same time frame and also acoustical and directional information. The coloured areas are thus purely an indication of group home range; only the triangulation points and the sightings are representative of when position was actually determined through calls or sightings. The coloured areas also indicate which of the triangulation points or sightings were attributed to which group. Triangulation points and sightings that could not be confidently assigned to a particular group remain unshaded on the map. Some ranges look larger than others (G13 and G17 in particular). This appears to be due to the fact that the ranges of these groups were closer to the listening posts and thus more data was collected on these groups. However, it is possible that G13 may in fact be two groups. In contrast, other groups appeared to have only one edge of their range within the effective listening area (see Section 2.7) and therefore only one or points were recorded for these groups (G3 or G4 for example).

(Insert map Fig 3.1)

3.2 Sightings

Over the twenty day research period eight sightings of nine groups occurred. Two group encounters were witnessed, between G5 and G6 and G10 and G19. These are marked on the map as possible boundaries between groups. Two lengthy sightings of G17 and one sighting of G13 confirmed that they were separate groups as the female of G17 has a ventral infant while the female of G13 does not. As the sightings of these two groups occurred within close proximity of one another (less than 200 metres), this has also been indicated on the map as a possible boundary between groups. In addition, one sighting of G9 occurred and one sighting of G15. There was also a sighting of an unknown group.

The sightings yielded an average group size of 3.4 individuals (n = 9 sightings). The smallest group sighted had two individuals and the largest had five individuals. For each individual, age and sex classes were assigned where possible (see Table 3.1).

Table 3.1   Age and sex class of gibbons seen

	No. of individuals
Adult females	9
Adult males	9
Sub-adult males	1
Sub-adult females	3
Adolescents	4
Juveniles	3
Infants	2
Total	**31**

Researchers managed to keep the gibbon group in question within their sight for a minimum of ten minutes and a maximum of forty-four minutes. The average length of time that the sightings lasted was 21.2 minutes (see Table 3.2). Sightings occurred during four of the five sample periods. No sightings occurred during the last sample period.

All sightings occurred either by tracking in on calling groups or while researchers were stationed at the listening posts. Four sightings occurred while researchers were stationed at the listening posts. Four sightings occurred by researchers tracking in on calling groups; these sightings occurred equal to or less than 300 metres from the posts. N = 8 sightings because two sightings were of four groups (two group encounters between two groups) and two sightings were of the same group.

Table 3.2   All gibbon sightings during research period (n=8)

Date of sighting	Length of sighting (mins)	Group name	Total no. of animals seen	Adult male	Adult female	Subadult male	Subadult female	Adolescent	Juvenile	Infant	**Notes**
01.07.04	27	G17	5	1	1		1		1	1	This is the same group, seen by different researchers and so counted only once
01.07.04	44	G17	5	1	1		1		1	1	
03.07.04	20	G15	4	1	1				1	1	
04.07.04	14	G13	4	1	1	1			1		
09.07.04	25	G5	4	1	1		1	1			Group Encounter
09.07.04	25	G6	3	1	1			1			
13.07.04	22	G9	3	1	1			1			
15.07.04	10	Unknown	4	1	1		1	1			
19.07.04	10	G10	2	1	1						Group Encounter
19.07.04	15	G19	2	1	1						
	Total		**31**	**9**	**9**	**1**	**3**	**4**	**3**	**2**	
	Mean group size		**3.4**								

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3.3 Density analysis

As was described in the methods, four density equations were used and generated the following results:

Density equation 1

$$D = \frac{n}{E}$$

where: D = density

n = no. of groups heard per sample period

E = effective listening area.

An effective listening area was calculated for each sample period, defined as the area within which at least two of the three teams of researchers could clearly hear calling gibbon groups up to a kilometre away; i.e. the proportion of the circles that overlapped. (see Section 2.7, Figure 3.3). 'E' was between 2.9 – 3.0 square kilometres for each sample period. The derived 'E' was then divided by the number of groups heard within the corresponding sample period (see Table 3.3, p. 35). The derived 'D' from each sample period was pooled (n=5) and divided by the number of sample periods (n=5) to give a density of 2.2 groups per square kilometre or 7.4 individuals per square kilometre.

Density equation 2

(Following the same method but incorporating the published correction factor (O'Brien *et al*., 2004)

$$D = \frac{n}{E} \times \frac{1}{p}$$

where: D = density

n = no. of groups heard per sample period

E = effective listening area

p = is the proportion of individuals expected to sing during one sample period (0.89).

This equation gives a density of 2.4 groups per square kilometre or 8.3 individuals per square kilometre.

Density equation 3

The third equation uses the visual representation of the results (see Fig. 3.1) to calculate the number of groups actually located within the two square kilometre area within which the listening posts were positioned.

$$D = \frac{n}{A}$$

where: D = density

n = no. of groups mapped within 2 km^2 area

A = 2 km^2 area encompassing the five sets of listening posts.

The no. of groups mapped within the 2 km^2 area was approximately 8 groups and A=4. The results are 2.0 groups per square kilometre or 6.8 individuals per square kilometre.

Density equation 4

(Incorporating the above correction factor)

$$D = \frac{n}{A} \times \frac{1}{p}$$

where: D = density

n = no. of groups mapped within 2 km^2 area

A = 2 km^2 area encompassing the five sets of listening posts.

p = is the proportion of individuals expected to sing during one sample period (0.89).

The results are 2.2 groups per square kilometre or 7.5 individuals per square kilometre. The density range incorporating the results from each method is 2.0 to 2.4

groups per square kilometre or 6.8 to 8.3 individuals per square kilometre. Individual

density for each equation is generated by multiplying group density by a mean group size

3.4 (n=9) generated from the sightings obtained during this study.

Table 3.3   Comparison of average group and individual densities with standard deviation

Listening post no.	Effective listening area Km^2	No. of groups	Without correction factor		With correction factor	
			Groups Km^{-2}	Individuals Km^{-2}	Groups km^{-2}	Individuals km^{-2}
1	3.0	5	1.7	5.7	1.9	6.4
2	2.9	5	1.7	5.9	1.9	6.6
3	2.9	8	2.8	9.4	3.1	10.5
4	3.0	7	2.3	7.9	2.6	8.9
5	3.0	7	2.3	7.9	2.6	8.9
		Mean	**2.2 $\pm$ 0.47**	**7.4 $\pm$ 1.55**	**2.4 $\pm$ 0.51**	**8.3 $\pm$ 1.74**

Table 3.4   Group and individual densities generated by estimating percentage of home range within a 2km^2 area

Defined area (km^2)	No. of groups	Without correction factor		With correction factor	
4	8	**2.0**	**6.8**	**2.2**	**7.5**

Approximate home range size for each group can be calculated using the density

estimate. As one square kilometre is equal to 100 hectares, home range is between 41.67

and 50.00 hectares per group.

3.4 Weather

Wind conditions were overwhelmingly calm (98 per cent, n=20 days) and thus had no

effect on calling frequency, song length or start times. Cloud cover was more variable, it

was clear on 35 per cent of days, more than 50 per cent cloud cover on 10 per cent of days

and less than 50 per cent cloud cover on 55 per cent of days (n=20 days). Cloud cover

appeared to have little effect on calling frequency, song length or start times. Temperature was not particularly variable, minimum temperatures averaged twenty-one degrees Celsius (range twenty to twenty-four degrees Celsius) and maximum temperatures averaged twenty-nine degrees Celsius (range twenty-seven to thirty-one degrees Celsius). Again, temperature had no effect on calling frequency, song length or start times.

The rain was heavy for the time of year; a total of 31.4 centimetres of rain fell during the research period (28 June – 27 July), twenty-one centimetres on data collection days. However, during the mornings on which data was actually collected, it never rained except for a slight drizzle on one occasion. Rainfall tended to occur during the late afternoon and particularly overnight. Rainfall during the night preceding data collection correlated with start times of calling (See Fig 3.2). In other words, gibbons started calling later on days when rain fell the night before. This correlation is significant (product moment correlation coefficient, $r_p = 0.519$, n= 20, p<0.02).
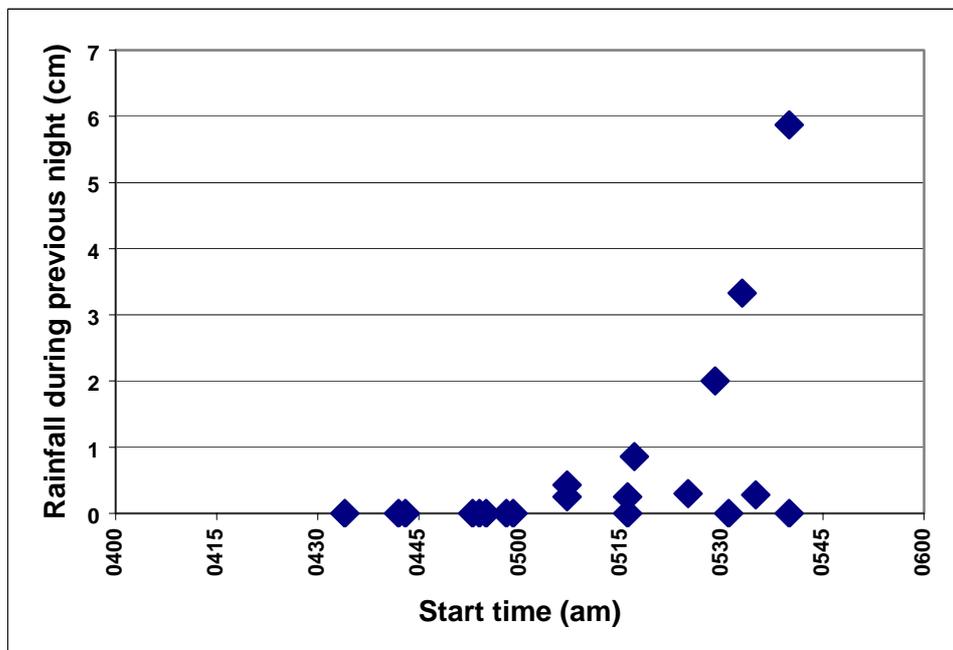
Fig 3.2   **Figure showing relationship between rainfall the previous night and start time of song bouts**

3.5 Ground surveys

Ground surveys took place between the hours of 1000 and 1500. Forty-five kilometres were walked on ten of the twenty data collection days. Researchers walked in the direction of calling groups, although researchers had to stick to the marked transects for safety reasons. No sightings of gibbons occurred during the ground surveys. Sightings of orang-utans (*Pongo pygmaeus*) and maroon-red surilis (*Presbytis rubicunda rubicunda*) did occur but were infrequent and there is not sufficient data to generate any kind of density figures.

3.6 Analysis of song bouts

Agile gibbons at Setia Alam called most frequently between 0500 and 0700 (73 per cent of calling). Start times prior to 0500 accounted for 12 per cent of all calling while 9 per cent of calling occurred between 0700 and 0800. Calls recorded after 0800 accounted for just 4 per cent of calling and calls recorded after 0900 accounted for just 2 per cent.

Mean start and stop times were calculated for both solo (all solo calls recorded were interpreted as male solos) and duet calls (see Fig. 3.3, p. 38). The median was also calculated, and is comparable to the mean (see Table 3.5, p 38). Mean song length was also calculated and averaged twenty-eight minutes for solo calls, and twenty-three minutes for duets. However, the range in length was great, five to fifty-six minutes for solos, and four to fifty-nine minutes for duets.
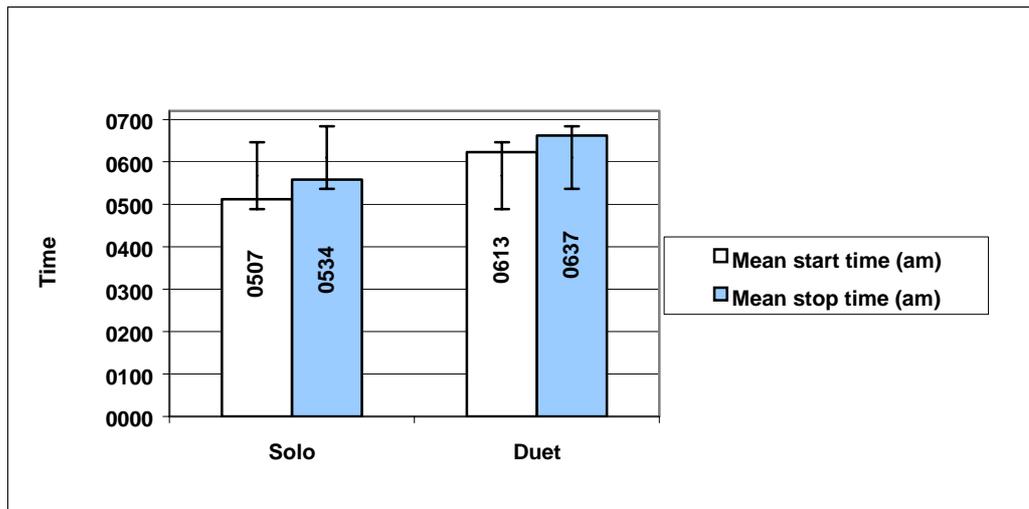
Fig 3.3   Mean start and stop times of gibbon song bouts with standard deviation

Table 3.5   Characteristics of gibbon song bouts

	Solo	Duet
Earliest start	0434	0437
Latest start	0548	0917
Mean start	0507	0614
Median start	0507	0608
Earliest finish	0507	0525
Latest finish	0648	1004
Mean finish	0535	0637
Median finish	0534	0626

	Solo	Duet
Mean song length	0028	0023
Median song length	0027	0019
Shortest song bout (mins)	0005	0004
Longest song bout (mins)	0056	0059

3.7 Probability of calling

The average probability of calling on any given day for agile gibbons at Setia Alam is 0.62 (n=20 days (see Appendix 7)). Across sample periods, the probability of calling on day one was 0.59 (±0.14, n=5 days). This rose to 0.92 (±0.11, n=10 days) by day two and was equal to 1.0 by day three (n=15 days) (see Table 3.6, p. 39). However, there was some variation;

four groups sang on all four days during the sample periods, eleven groups sang on three of four days, eleven groups sang on two of four days and five groups sang on just one of four days (n=31, as some groups were heard during more than one sample period).

For sample periods one, two and five, all groups mapped within the effective listening area were heard by day two. For the remaining two sample periods (three and four), all groups within the effective listening area were heard by day three.

Table 3.6   Average probability of calling rates with standard deviation

	Probability of calling by Day 1	Probability of calling by Day 2	Probability of calling by Day 3
Sample period 1	0.80	1.00	1.00
Sample period 2	0.40	1.00	1.00
Sample period 3	0.63	0.75	1.00
Sample period 4	0.57	0.86	1.00
Sample period 5	0.57	1.00	1.00
Average	**0.59**	**0.92**	**1.00**
Standard deviation	**±0.14**	**±0.11**	**0**

Chapter 4 – Discussion

These results indicate that a healthy population of *Hylobates agilis albibarbis* exists in the Sebangau region. Mapping of calls over the twenty day research period located nineteen groups, and nine of these groups were seen. The density estimates produced a density range of 2.0 to 2.4 groups per square kilometre or 6.8 to 8.3 individuals per square kilometre. Mean group size based on sightings is 3.4 individuals. A simultaneous study occurred at the same site using the line transect method to generate mammal densities. Preliminary results for the agile gibbon yielded a group density of 1.1 and an individual density of 3.3 (Teixeira, pers. comm.).

4.1 Auditory sampling principles and findings in reference to this study

Brockelman and Srikosamatara (1993), assess the validity of auditory sampling for gibbons in a study of known groups. Many of their guidelines for successful auditory sampling were adhered to during this research.

Weather has been shown to affect singing frequency (Raemaekers, Raemaekers and Haimoff, 1984; Brockelman and Ali, 1987; Leighton, 1987; Brockelman and Srikosamatara, 1993). Although it did rain during this study, it did not rain during data collection. Rain preceding data collection (the night before) was shown to correlate with start times but had no effect on singing frequency. In contrast, O'Brien *et al*., (2004) showed that rainfall during the twenty-four hour period prior to data collection had no effect on start times or calling frequencies for siamangs or agile gibbons. However, the study does not quote rainfall levels, so it may be that rainfall was significantly heavier during my study, but this hypothesis can not be tested.

Cloud cover exceeding 50 per cent accounted for more than half of the data collection days in my study. However, there was no correlation between cloud cover and singing frequency, start times or song length. In contrast, Brockelman and Srikosamatara (1993) showed a correlation between singing frequency and cloud cover for pileated gibbons (*Hylobates pileatus*). O'Brien *et al*. (2004) showed a weak correlation between cloud cover and calling for agile gibbons, but not for siamangs.

During this research, wind conditions were overwhelmingly calm (98 per cent of days) and thus had no effect on singing frequency, start times or song length. Similarly, O'Brien *et al*. (2004) found that wind had no detectable effect on singing frequencies for agile gibbons. In contrast, the same study showed that windy conditions were negatively correlated with siamang calling frequencies. Other studies have also shown that wind markedly inhibits singing; pileated gibbons sang, on average, on only 3.9 per cent of windy days in comparison to 62.3 per cent of calm days (Brockelman and Srikosamatara, 1993). However, wind during my study was only recorded categorically (calm, breezy and windy). Recording wind speeds would have been a more accurate method, and may have shown a correlation.

Comparison of this study and the three studies cited above indicate that it is important to record the weather during auditory sampling as it can act as a variable on start times, singing frequency or song length. Fortunately, no 'bad weather' days had to be excluded from my analysis (Brockelman and Ali, 1987; Brockelman and Srikosamatara, 1993). Weather conditions during this study thus seemed appropriate for auditory sampling methods as compared to the other studies. Unfortunately, comparison is limited to these three studies as none of the other gibbon auditory surveys consulted (Haimoff *et al*., 1986; Alfred and Sati, 1990; Nijman, 2004) commented on weather as a possible bias or variable. Similarly, surveys employing auditory sampling methods consulted for other vocal

primates including *Alouatta pigra* (Estrada *et al*., 2002; Estrada *et al*., 2004), *Tarsius spectrum* (Gursky, 1998) and *Macaca fuscata* (Hanya *et al*., 2003) did not comment on the weather conditions during the research period, and whether it affected calling behaviour.

4.2 Problems and possible bias associated with this study

Due to time restraints, researchers were unable to determine singing frequencies prior to data collection, a recommendation that is commonly made for auditory sampling methods (Brockelman and Ali, 1987; Brockelman and Srikosamatara, 1993; O'Brien *et al*., 2004). However, studies that have employed this technique are assuming that the frequency generated is representative of the study area as a whole (Brockelman and Srikosamatara, 1993). Singing frequencies for this data were calculated post data collection, following the first of two methods proposed by Brockelman and Srikosamatara (1993). Groups were recognised individually using directional and acoustical information. Therefore it was possible to work out which groups sang on which day. The advantage of generating calling frequencies post hoc is that the data are from the area to which the density estimates correspond. In addition, accuracy of calling rates increases when more than ten gibbon groups are used in the calculation (Brockelman and Srikosamatara, 1993). The results from this study are based on nineteen groups.

Weather conditions were difficult during the research period. It rained on twelve of the twenty data collection days, and particularly during the latter stages of the research period, the forest was muddy and flooded (often well above knee height). Researchers often arrived cold and wet at the listening posts, after a long walk through the forest in the dark, and this may have affected concentration. Conditions in the forest also made it very difficult for researchers to move quietly about the grid system. This relates to one of the assumptions of the technique outlined in the methods (see Section 2.16); that locations of

animals are not influenced by observers (Hanya *et al*., 2003). This is difficult to test, but it must be noted that the animals were not habituated and due to the weather conditions, it is very possible that this assumption was violated.

Researchers camped in the forest at a pondok during the third sample period, and despite the initial disturbance of setting up camp, researchers walked a maximum of 350 metres in order to reach the listening posts. This meant that they could be much quieter, walk at a slower pace and had less chance of disturbing gibbons or other wildlife en route to the listening posts. For the other research periods, researchers walked up to two kilometres from base camp in order to reach the listening posts. Unfortunately, the practical implications of staying out in the forest (equipment and provisions needed) precluded the opportunity of camping out for any of the other sample periods.

There were large numbers of researchers involved in this project, many of whom were inexperienced, both in terms of the methods employed and also in relation to the forest and the habitat that we were working in. Steps were taken to avoid any inconsistencies, namely, three days of data collection at the start of the research period that were not used in the density analysis in order to identify any problems, and the employment of three team leaders who were responsible for recording the compass bearing of, and estimated distance to, calling gibbon groups. The second member of each research team simply recorded the data on the data collection sheets and was mainly present for safety reasons, since researchers could not work alone in the forest. As the three team leaders were recording information from different locations, it was impossible to test inter-observer reliability among researchers. It was, however, ensured that team leaders used exactly the same equipment and the modification of the technique by recording compass bearings at three minute intervals helped to ensure that researchers were definitely recording the same gibbon groups, by comparing start and stop times, occurrence and

frequency of great calls, and other acoustical information such as the presence of immatures who joined in with vocal behaviour. Researchers could then be confident of the identity of groups before the triangulation points were plotted on a map. I would recommend that this technique be replicated for auditory sampling if the researchers are inexperienced in any way.

The distance among listening posts varied by up to 300 metres, both within and across sampling periods. The restraints of the grid system at the research site made this impossible to avoid, and researchers were advised to locate listening posts on transects for safety reasons. However, this did not significantly alter the effective listening area for each sample period, which only varied between 2.9 and 3.0 square kilometres. The fifth set of listening posts was closest to each other in distance (see Table 2.1, p. 14) but this had no significant effect on the effective listening area either. In fact, it succeeded in creating a larger area of overlap where all three groups of researchers could hear gibbon groups calling up to one kilometre away. Brockelman and Ali recommend a distance of 300 to 600 metres between listening posts. For flat terrain such as is typical of this study, I would recommend a decrease in this distance to between 200 and 300 metres, as gibbon calls carry over shorter distances in level forest.

The accurate estimation of distance to calling groups or individuals was one of the hardest elements of this study. Difficulties in estimating distances when animals are detected by auditory cues have been found by other researchers (Hanya *et al*., 2003). As triangulation was used, density estimates were not relied upon. Therefore, I would recommend triangulation (three groups of researchers) for a study of this nature.

A disadvantage of researchers tracking in on singing gibbon groups to obtain sightings was that researchers had to leave the listening post and thus there would be a period of time within which the research team in question did not take compass bearings.

This restricted the distance that researchers could track and the amount of time spent involved in this activity. Suggestions for how this problem could be solved are discussed in the concluding chapter.

4.3 Sightings

Considering that the gibbons at Setia Alam are completely unhabituated, and that gibbons are known for unreliable behaviour upon detection (Brockelman and Srikosamatara, 1993), it was doubtful in the early stages of data collection whether any sightings would occur. The decision to track in on calling groups (provided they were located less than 300 metres from the listening post) proved successful and resulted in four sustained sightings of five groups (as one of the sightings was a group encounter involving two groups). Tracking singing groups has several advantages:

1) Vocal behaviour allows researchers to locate groups efficiently and quickly (Alfred and Sati, 1990).

2) Whilst gibbons are engaging in vocal behaviour, researchers are able to approach by stealth and get within close proximity to the group before the animals become aware of their presence, essential for non-habituated groups (Haimoff *et al*., 1986).

3) Vocal behaviour aids identification, particularly of the adults and sub adults (Haimoff *et al*., 1986).

These sightings lasted between fourteen and twenty-five minutes. Researchers made efforts to remain concealed to prolong the sighting (Raemaekers, Raemaekers and Haimoff, 1984; Haimoff *et al*., 1986). Once gibbon groups spotted researchers, they tended to continue to call but changed to disturbed call bouts (as defined by Raemaekers, Raemaekers and Haimoff, 1984), which are triggered by aversive stimuli, human presence in this context. If the gibbon group in question moved on, no further

attempts to follow were made, as researchers did not want to distress the gibbons. Unhabituated gibbons typically give three responses upon detection: 1) they flee silently, 2) they give disturbed call bouts in situ, 3) they move away and then give a disturbed call bout (Raemaekers, Raemaekers and Haimoff, 1984). Although sightings during this study were not frequent enough to draw any definite conclusions, the gibbons at Setia Alam tended to offer the second response if they were detected whilst singing and the first or third response if detected while not singing.

Sightings also occurred while researchers were stationed at the listening posts. This accounted for four sightings of four groups; two sightings of the same group occurred at different posts, one sighting of one group and one sighting of two groups (another group encounter). This proved to be another successful way of achieving sightings, although it was dependent upon researchers being very quiet whilst at the posts. Sightings of orang-utans (*Pongo pygmaeus*), pig-tailed macaques (*Macaca nemestrina*) and maroon-red surilis (*Presbytis rubicunda rubicunda*) also occurred at the listening posts.

Gibbon sightings at listening posts lasted between ten and forty-four minutes. Researchers remained stationed at the post while the sightings occurred, with the exception of the longest sighting when researchers followed the group approximately forty metres from the listening post. This was G17, the group whose range is closest to base camp. This group is thus slightly more tolerant of human presence.

4.4 Group encounters

Two group encounters were witnessed during the research period. Researchers are confident that they were witnessing two groups meeting each other at possible boundaries of each group's territories and not one large group calling for the following reasons:

1) Great calls by the females of each group followed each other and were not synchronised, as they would have been if it were a younger female singing behind her mother. Great calls are given during group encounters (Gittins, 1980; Gittins, 1984) but are sung in response to the female from the other group, not at the same time (Gittins, 1980; Gittins, 1984).

2) The males of each group were seen and heard giving conflict 'hoos' and 'whistles' (Gittins, 1984; Reichard and Sommer, 1997), which are unique to this context.

3) The groups in question moved off in different directions from each other after the encounter had ended (Gittins, 1980).

4) No actual chasing occurred ; although the males stared at each other and males and females from both groups brachiated within their adjacent trees. This is similar to Reichard and Sommer's (1997) findings of encounters between lar gibbon groups, where in up to three quarters of all encounters between groups members stared at each other and brachiated without actually reducing the distance between groups (Reichard and Sommer, 1997). Gittins (1983) and Leighton (1987) also found that sitting was the most common posture for agile gibbons during group encounters.

5) The first witnessed encounter occurred between 0845 and 0910. The second witnessed encounter occurred between 0540 and 0604. Although the sample is too small to draw any definite conclusions, Reichard and Sommer (1997) found that encounters between lar gibbon groups peaked during 0630 and 0759. In contrast Gittins (1980), found that encounters between agile gibbon groups occur with equal probability at any time of the day.

In terms of the social organisation of the gibbon population at Setia Alam, this indicates that there is some overlap among group home ranges, as group encounters are

unlikely to be witnessed in areas of very low density (Gittins and Raemaekers, 1980; Cheyne, pers. comm.).

4.5 Line transects and ground surveys

Ground surveys did not prove to be a successful method for sighting gibbon groups. They took place after the majority of vocal behaviour had ceased for the day. Although researchers walked in the direction of groups that had called earlier that day, groups had clearly moved on by the time researchers reached the location. Even if the group in question was moving in the direction of researchers, it is likely that the gibbons spotted researchers prior to detection and fled silently. Ground surveys combined with auditory sampling have proved successful for other vocal monkeys, notably black howler monkeys (*Alouatta pigra*) (Estrada *et al*., 2002; Estrada *et al*., 2004). The main problem associated with ground surveys for locating gibbon groups is that gibbons are particularly fast movers. Agile gibbons can take as little as ten to fifteen minutes to cross their range (Leighton, 1987).

As previously stated, a mammal survey was being conducted at the same time as my study using the line transect method. Isolating only the results regarding gibbon sightings, researchers walked 173 kilometres of transects and sighted gibbons on fifteen occasions (a total of forty three animals). This was more successful than the ground surveys when researchers walked a total of forty-five kilometres resulting in zero sightings. This may have been due to the timing, as line transects took place between 0600 and 1000 hours, whereas the ground surveys took place between the hours of 1000 and 1500. Haimoff *et al*. (1986) conducted morning and afternoon walks in search of gibbons and no sightings ever occurred during the afternoon walks.

The results from the line transect survey produced a lower density estimate than the auditory sampling method employed in my study (1.14 groups km^{-2} and 2.2 groups km^{-2} respectively). There were some apparent problems with the results of the line transect method, including a large estimated strip width of 37.7 metres, which would have lowered the density estimate, possibly due to overestimating distances (Husson, pers. comm.). Gibbon sightings during the line transect method were brief and researchers never saw groups of more than three individuals. This resulted in a mean group size of 2.87 individuals as opposed to 3.4 individuals in this study. Although this is only a brief comparison of results, it does indicate that auditory sampling methods are more successful for gibbon surveys, especially when the gibbons are not habituated and when the time frame for the research is restricted. The line transect method has previously been shown to underestimate gibbon density (Marsh and Wilson, 1981, cited in Brockelman and Srikosamatara, 1993).

As previously stated, triangulation has also been successfully employed in black howler monkey surveys, in combination with ground surveys (Estrada *et al*, 2002; Estrada *et al*, 2004). In contrast, Gonzalez-Kirchner (1998) used only direct sightings and not vocalisations in the density analysis in a survey of the same species. Unfortunately, none of the researchers discuss the reliability of their respective techniques.

For gibbon surveys, researchers seem to employ auditory, as opposed to visual cues, more frequently. Haimoff *et al*., (1986) located twenty groups during a survey of black-crested gibbons (*Hylobates concolor concolor*) through auditory cues. Of these, only six groups were sighted. These results are even lower than the results from my study, where eight of the nineteen located groups were sighted. The survey took place in mountainous terrain where the gibbons were unhabituated, thus only spot observations were possible (Haimoff *et al*., 1986). Similar to my study, the most direct and prolonged

sightings took place while the gibbons were calling (Haimoff *et al*., 1986). Alfred and Sati (1990) did use sightings and follows to obtain density estimates of hoolock gibbons (*Hylobates hoolock*) in Northeast India. Presumably, the gibbons were not habituated, but researchers did employ the services of a local guide with a good knowledge of the area (Alfred and Sati, 1990). In addition, whilst observing one group, researchers noted the direction of calls from other groups, in order to facilitate finding those groups on the following day (Alfred and Sati, 1990).

Other surveys of vocal primates have combined the use of auditory and visual cues to useful effect. Gursky (1998) used the quadrat census and a modified form of the fixed point count to survey tarsiers (*Tarsius spectrum*). As tarsiers return to sleeping sites, they give calls that can be heard up to 300 to 400 metres away. From this information, locations and the number of groups within each one hectare plot was determined. Prior to dusk, observers would also count the number of individuals leaving each sleeping tree, noting age and sex classes (Gursky, 1998). Hanya *et al*., (2003) combined a point census with group follows to obtain density estimates for Japanese macaques (*Macaca fuscata*). The census area was divided into squares and an observer was positioned in each grid to record sightings and vocalisations.

My study is similar to the two studies outlined above in the sense that it combined two techniques. Density estimates were obtained through the mapping of calls and information on group size, and age and sex classes were obtained by tracking in on calling groups (allowing researchers to get close before gibbon groups were alerted) and through opportunistic sightings occurring at the listening posts, where detection was not compromised by the noise of walking on uneven terrain (Ross and Reeve, 2003). I would advocate this technique over the line transect method, especially when the research period is restricted. As calls can be heard over greater distances than are detectable by sight, the

inclusion of auditory cues increases the sample size of encounters (Davies, 2002).

Moreover, sightings are still obtained by including the other techniques outlined above,

and are more prolonged than the brief sightings obtained during line transects. Estimates of

group size during line transects are likely to be inaccurate, unless there are several

observers and one leaves the transect to follow the group of monkeys or apes (White and

Edwards, 2000c). This is demonstrated by the comparison of the surveys carried out at

Setia Alam, as the mean group size obtained by the line transect method was lower than

the mean group size in this study. Moreover, sightings of one gibbon were included in the

line transect survey (Husson, pers. comm.), and yet the density estimate generated referred

to groups per square kilometre. This does not allow for the exclusion of dispersing

individuals in the density analysis as is the case with the auditory sampling method

employed in my study.

4.6 Probability of calling

Probability of calling for *H. a. albibarbis* on any given day at Setia Alam varied from 0.29

to 1.0, but averaged 0.62 (±0.18, n=20 days) (see Appendix 7). A smaller variation of 0.57

to 0.85 was found for lar gibbons (*Hylobates lar*) across a range of study sites (Brockelman

and Ali, 1987) but the average is similar, 0.69. Pileated gibbons (*Hylobates pileatus*) also

show variation in daily singing frequency, 0.23 to 0.61 and a lower average, 0.43

(Brockelman and Srikosamatara, 1993). Average probability of calling rates for siamangs

on any given day is 0.25 (±0.12, O'Brien *et al*., 2004). The same study generated average

probability of calling rates for agiles on any given day, which was 0.42 (±0.24, O'Brien *et

al*., 2004). This is lower than the results from my study, although it is a different sub-

species (*H. a. agilis*).

Cumulative calling frequencies were generated by my study. Across sample periods, the average probability of calling ≥ 1 time per 2-day sample period was 0.92 (±0.11, n=10 days). After three days the likelihood of calling ≥ 1 time was 1.0 (n=15 days) (see Table 3.6). In contrast, O'Brien *et al*. (2004) found the average probability of calling ≥ 1 time per 3-day sample period for agiles to be 0.75 (±0.19) and 0.89 (±0.13) after four days. Although my results are higher, direct comparisons are not possible as the results from the O'Brien study are based on 12 gibbon groups from one census point (a calibration trial) and a listening radius of two kilometres. My results are based on nineteen gibbon groups from five averaged census points (each sample period) and a listening radius of one kilometre.

Other possible reasons for these variations include independent responses to weather and mutual stimulation (Brockelman and Srikosamatara, 1993). A further hypothesis could involve group composition, in the sense that groups with more members who sing may be motivated to sing more (personal observation). However, the sample size of this study is too small to test this hypothesis.

4.7 Analysis of calling

Analysis of song bouts during this research can also be compared with other sites. Table 4.2 compares time blocks of calling in this study with another site in Central Kalimantan. Calling prior to 0500 accounted for 12 per cent of calls, whereas in Bukit Baka Bukit Raya National Park no calling before 0500 was recorded (Cheyne, 2004). As start times were shown to correlate with rainfall the previous night during my study, and all calling before 0500 occurred when no rain had fallen the previous night, this percentage may have been even larger had the rainfall been more typical of the season.

In contrast, Bukit Baka Bukit Raya National Park had a higher percentage of calling occurring after 0800. At Setia Alam, the majority of calls were restricted to the 0500 to 0700 time block. It is possible that different forest types, altitude and latitude accounts for the differences in calling times between these two sites (Cheyne, per comm.).

Table 4.1   Comparison of time blocks within which calling occurred.

Time block	Percentage of calls at Bukit Baka Bukit Raya National Park, Central Kalimantan. Reference: Cheyne, 2004	Percentage of calls at Setia Alam Field Station, Central Kalimantan Reference: This study
Before 5am	0	12
5-7am	46	73
7-8am	25	9
After 8am	18	4
After 9am	11	2

Male solos at Setia Alam on average occurred earlier than the duets (0507 and 0548 respectively). Raemaekers, Raemaekers and Haimoff (1984) found the same pattern for *Hylobates lar*. Median song length for solos during this study was twenty-seven minutes, comparable to other agile gibbon studies (twenty-six minutes, Gittins, 1984). However, range in solo song length is large (five to fifty-six minutes, my study; three to ninety-one minutes, Gittins, 1984). Solo calling often began before first light in my study. The same pattern has been found at other sites (Raemaekers, Raemaekers and Haimoff, 1984).

Median song length for duets in my study is nineteen minutes. Comparisons with Gittins (1984) is complicated by the fact that researchers differentiated between dawn and morning duets. Median song length was seventeen minutes for dawn duets and eleven minutes for morning duets (Gittins, 1984). My study did not make that distinction, but it is clear from the results that duets were longer in general at Setia Alam. Duets only started

after sunrise. One reason that this occurs is that coordination between the sexes and brachiating requires good visibility (Raemaekers, Raemaekers and Haimoff, 1984).

4.8 Density estimates

With reference to the results section, a range of density estimates was generated by four different methods. However, the estimate of 2.2 groups per square kilometre has been selected as the most reliable estimate as it is generated from the following techniques:

1) Calculating an effective listening area for each of the five sampling periods.

2) Calculating a density per sample period based on the number of groups heard and the effective listening area.

3) Averaging the density estimates from each sample period.

4) Not applying a correction factor.

Thus, for the remaining part of the discussion, it is this density estimate that will be referred to.

Low density has also been proposed to affect singing frequency, as groups with few neighbours may sing less than groups surrounded by neighbours (Brockelman and Srikosamatara, 1993). Thus there is a danger of underestimating densities in areas of low density. However, Brockelman and Srikosamatara (1993) consider a density of less than two groups per square kilometre as low, and the estimate from this study exceeds that figure. In addition, two group encounters involving four different groups were witnessed during this research, indicating that even if group ranges are not overlapping (ranges can overlap by up to 30 per cent in high density areas (Sommer and Reichard, 2000)), they are at least coming within close proximity of each other. Moreover, some research shows that for agile gibbons, singing is spontaneous and not stimulated by neighbouring groups (Brockelman and Ali, 1987).

Individual density of 7.4 animals per square kilometre was calculated from a mean group size of 3.4 individuals, generated by the data corresponding to the eight sightings of nine groups that occurred during the research period. Previous research on mean group size of *H. a. albibarbis* in West Kalimantan, Borneo (Mitani, 1990), yielded an average group size of 4.1. This figure is higher than the data generated by my study. However, Mitani's research period was much longer and the density is higher in that region (a mean of 14.9 individuals per square kilometre). It is possible that some individuals of each group sighted were missed during my study, as the gibbons at Setia Alam are not habituated. In addition, agile gibbon group members can be up to thirty metres apart at any given time (Gittins and Raemaekers, 1980). However, mean sighting length was 21.2 minutes, so these were sustained rather than brief sightings. It was decided that the mean group size generated by this data would be used in the density analysis, as opposed to referring to published data, as there is no evidence to suggest that mean group size is consistent across study sites. In fact, there is huge variation regarding density, group size and range size across sites, even if only *Hylobates agilis* is considered (See Table 4.2).

Table 4.2 Comparison of densities and home range size for *Hylobates agilis* across study sites

Species	Location of study site	Average Group density km^{-2} N= No of groups studied	Animal density km^{-2}	Mean group size	Home range (hectares)	Reference	Habitat type
Hylobates agilis albibarbis	Setia Alam Field Station: Central Kalimantan, Borneo	2.2 (N=19)	7.5	3.4	45	This study	Peat Swamp Forest
Hylobates agilis albibarbis	Gunung Palung Reserve: West Kalimantan, Indonesia	3.6 (N=10)	14.9	4.1	28	Mitani, 1990	Mountain forests. Also beach and mangrove forests, peat and freshwater swamp forests and lowland rainforests
Hylobates agilis albibarbis	Tanjung Puting National Park, South Kalimantan, Borneo	-	8.7 (N=16)	-	-	Mathers, 1992	Primarily heath forest, also Nypa forest, mangrove and peat swamp forest
Hylobates agilis x *Hylobates muelleri*	Barito Ulu Research Area: Central Kalimantan, Borneo	2.1 (N=?)	8.2	4	43-46	McConkey *et al.*, 2002	Lowland dipterocarp and heath forest
Hylobates agilis agilis	Bukit Barisan Selatan National Park: Southwest Sumatra	0.7 (N=?)	1.4 -2.2	2.61	-	O'Brien *et al.*, 2004	70 per cent dipterocarp, forest, also beach forest, freshwater swamp forest, Nypa forest and hill and mountain forest
Hylobates agilis unko	Sungai Dal, Gunung Bubu Forest Reserve: West Malaysia	4.3 (N=7)	18.9	4.4	29	Gittins and Raemaekers, 1980, Gittins 1982	Lowland and hill dipterocarp forest

Of the other studies cited, only one exclusively focused on surveying a gibbon population (O'Brien *et al*., 2004). The other studies looked at gibbon fruit selection (McConkey et al., 2002), demographic processes (Mitani, 1990), and gibbon social organisation, feeding and ranging behaviours (Gittins and Raemaekers, 1980; Gittins, 1982). For this reason, the number of groups studied is either smaller than my study or not stated. In addition, the data for some categories was not available. Moreover, no population estimates are included with the exception of O'Brien *et al*. (2004) who estimates a population of 4,479 individuals in a national park in Sumatra (*H. a. agilis*). With reference to habitat types, only the study site that formed the focus of my study is exclusively peat swamp forest, highlighting the uniqueness of this habitat type for gibbon taxa.

Home range size for my study generated by the group density estimate of 2.2 groups per square kilometre gives a home range of forty-five hectares. Although this is within the upper scale of published range sizes for gibbons across species (seven to fifty-eight hectares: Leighton, 1987), it is not as high as the original estimates for this site (Cheyne, pers. comm.). Moreover, as the gibbons at Setia Alam compete for food resources with orang-utans, it is expected that their range would be slightly larger than gibbons that inhabit forests without the presence of orang-utans. Research by Rodman (1978) shows that spatial distribution of sympatric primates is correlated with dietary preferences. McConkey *et al*. (2002) discuss differences in competition pressure at difference sites and hypothesise that the hybrid gibbons (*Hylobates agilis* x *Hylobates muelleri*) at Barito Ulu are more selective in their fruit choices because they do not have to compete with orang-utans. It is worth noting, though, that range size of the gibbon groups at Barito Ulu is similar to the results of this study (see Table 4.2).

4.9 Extrapolation of density estimate

As previously mentioned, this study was conducted within one of the three main habitat subtypes that make up the Sebangau ecosystem: mixed swamp forest (MSF). Extrapolation of these results is therefore restricted to this habitat subtype. MSF at this site totals 2622 square kilometres. This gives a gibbon density of 5768 individuals. However, long term monitoring of orang-utan densities in the Sebangau region from 1996 to the present found a further distinction within MSF between perimeter mixed swamp (defined as one to three kilometres from the Sebangau river) and interior mixed swamp (defined as four to six kilometres from the Sebangau river) (Husson *et al*., 2004). Researchers found significant differences in orang-utan density between the interior and the perimeter; the densities were higher in the interior in 1999 and 2000, and then higher in the perimeter from 2001 to 2003 (Husson *et al*., 2004). My study was confined to perimeter mixed swamp forest, as this is where the grid system is located. Perimeter mixed swamp forest accounts for half of the total MSF area :1311 square kilometres. For this area the gibbon population is estimated at 2884 individuals. It is impossible to postulate from these results whether gibbon density is consistent throughout the mixed swamp forest area, or whether gibbon density also varies between perimeter and interior mixed swamp forest.

The other two major habitat subtypes within the Sebangau are low pole forest (LPF) and tall interior forest (TIF). Orang-utan densities have been generated for these two habitat subtypes also, during the same time frame (Husson *et al*., 2004). In relation to MSF densities, researchers found orang-utan densities to be higher in the TIF and lower in the LPF. Again it is impossible to say, on the basis of these results, whether gibbon densities follow the same pattern; although during the biodiversity survey in 1997, gibbons were seen more in the tall interior than the mixed swamp and not seen or heard in the low pole

(Page *et al*., 1997). This is certainly an area worthy of further research and this will be discussed in more detail in the concluding chapter.

4.10 Conservation implications for *Hylobates agilis albibarbis*

In 1977, Chivers estimated the *Hylobates agilis* population to be in the region of 744,000 individuals. He attributed 455,000 of these individuals as belonging to the *Hylobates agilis albibarbis* subspecies. His predictions for the future of this species were bleak, and the article predicted a 95 per cent loss of the *albibarbis* subspecies over the following ten to fifteen years. However, a later article by the same author stated that the status for *H. a. albibarbis* was 'widespread' and 'relatively safe' (Brockelman and Chivers, 1984, p.4). In 1986, MacKinnon published similar, but slightly higher, population estimates for *Hylobates agilis*, in the region of 850,000. However, this article does not differentiate between the different subspecies of *H. agilis*. Both articles warn of the crudeness and possible inaccuracy of the data (Chivers, 1977; MacKinnon; 1986). Chivers (1977) states that the numbers are likely to be overestimates.

To the best of my knowledge, population estimates of *Hylobates agilis* have not been published since. IUCN stress the importance of re-evaluating taxa at regular intervals, particularly those that are listed as 'Near Threatened' or 'Conservation Dependent'. IUCN last assessed *Hylobates agilis albibarbis* in 2000 (Eudey, 2000). The paucity of data discovered during the study does question the validity of the IUCN classification.

Moreover, with the exception of North Vietnam, gibbon distribution (and thus presumably abundance and viable population estimates) is most poorly documented for Borneo (Brandon-Jones *et al*., 2004). Gibbon distribution that has been documented for Borneo shows a coastal bias in terms of information (Marshall and Sugardjito, 1986; Brandon-Jones *et al*., 2004).

The density figures generated by this study are encouraging and indicate that peat swamp forest is an important habitat for gibbons. However, without protection efforts, it cannot be certain that the Sebangau ecosystem will remain. Illegal logging presents the biggest problem. Husson *et al.* (2004) identify as an immediate conversation priority the damming of illegal logging extraction canals in an attempt to restore the hydrology of peat swamp forest within the Sebangau. Bat catching and the harvesting of non-timber products such as bark, rattan and latex also continue to take place within the Sebangau catchment area (Morrogh-Bernard *et al.*, 2003).

The demographic processes demonstrated by gibbons makes this species particularly susceptible to population crashes (Mitani, 1990). This is worrying, as much of the habitat occupied by gibbons continues to be destroyed (Mitani, 1990). Monitoring over time would assess the stability of the Sebangau population. Monitoring would also assess whether the Sebangau gibbon population has reached carrying capacity. A shortage of suitable habitat affects survival rates of dispersing individuals (Mitani, 1990).

People are slow to realise that large tracts of forest are essential for our survival (Chivers, 1977). The environmental benefits and importance of peat swamp forest have been well documented (MacKinnon *et al.*, 1997a; Page *et al.*, 1997, Morrogh-Bernard, 2003). Moreover, the Sebangau ecosystem is unique as gibbon habitat, as gibbons do not usually inhabit peat swamp (Chivers, 1997). This area could represent one of the largest continuous populations of *H a. albibarbis* in Borneo. It is hoped that this data will help to ensure that plans to protect the Sebangau ecosystem are put into effect.

Chapter 5 – Conclusions and Recommendations

5.1 Major outcomes

The major outcomes of this project are as follows:

1) *Hylobates agilis albibarbis* are present within the Sebangau region, estimated at a density of 2.2 groups per square kilometre. This density lies in the mid range of published density estimates for agile gibbons across study sites.

2) Extrapolation of results indicates a population in the region of 5700 individuals (mixed swamp forest only).

3) Calling times were shown to correlate with rainfall during the night preceding data collection.

4) On the basis of this study, auditory sampling methods are preferable to line transects when surveying gibbon populations.

5) Auditory sampling methods can be used to survey gibbons in level forest, although adjustments are necessary. The effective listening area is reduced and three listening posts for each sample period are recommended.

6) Probability of calling rates generated by this study indicates that 3-day sample periods would be sufficient.

7) Weather should be recorded during data collection, as should temperature and rainfall.

5.2 Suggestions for further study

Further research should extend the survey area to establish whether there are differences in gibbon density between the interior mixed swamp forest and the perimeter mixed swamp forest. Surveys within LPF and TIF would also be useful to establish the presence or

absence of gibbon groups in LPF and densities of gibbon groups in TIF. These data would facilitate comparison of densities across habitat subtypes. TIF is of particular interest as it is a dry, tall, species rich habitat that not only has the highest recorded diversity and abundance of flora and fauna for deep-peat swamp forests (Husson *et al*., 2004), but also is a habitat subtype that is thought to be unique to the Sebangau region (Husson *et al*., 2004).

Further gibbon surveys within LPF and TIF are possible. Access is difficult, and the TIF takes two days to reach from base camp on foot (personal observation), but orang-utan nest resurveys regularly take place in these areas (Husson and Morrogh-Bernard, pers. comm.). Pondoks are present within LPF and TIF and could be used in a similar way as during the third sample period of this survey.

For further research, optimal research team numbers would include a tracker at each listening post who could track in on calling groups while the other researchers remained at the listening posts to record compass bearings and approximate distance of groups from the post. This would also be a useful way of testing the accuracy of the data, as regular sightings could confirm the location of calling groups.

The benefit of long term monitoring of orang-utan populations within the Sebangau ecosystem has been demonstrated through the work of Husson and Morrogh Bernard from 1996 to the present. This research showed that the orang-utan population suffered a significant decline during 2000-2001 due to illegal logging on a large-scale (Husson *et al*., 2004). Orang-utan density and distribution among habitat subtypes also altered dramatically over this period (Husson *et al*., 2004). Researchers attribute these patterns to the 'compression effect', which occurs when orang-utans are compressed into refuge areas to escape logging pressure (Husson *et al*., 2004).

The only data available on gibbon densities is that which has been generated by this study. We do not know what happened to the gibbon population during this period nor

since. It could be that they suffered a similar loss, or that, due to their smaller interbirth interval and higher rates of population growth relative to orang-utans, their population actually expanded to fill the available niche (Husson *et al*., 2004). However, the interbirth interval for gibbons is long compared to many other primates (see Section 2.4). Mitani (1990) demonstrated that agile gibbons in Gunung Palung Reserve showed a top-heavy age class pyramid, which is not conducive to population growth. Surveys on a larger scale, and long-term monitoring of the gibbon population within the Sebangau are vital in order to assess its viability.

O'Brien *et al*. (2003) stress the importance of longitudinal studies in order to assess the consequences of habitat disturbances on wildlife populations. Some studies show that gibbon populations are fairly tolerant of logging, at least at low levels of extraction (Chivers, 1986). When logging occurs, gibbons stay within their territories and seem reluctant to move beyond their territorial boundaries (Wilson and Johns, 1982). Their locomotive capabilities may also be important in enabling them to continue to move around in logged forest, despite the fact that a number of arboreal pathways may have been disrupted.

This study attempted an intensive survey of the grid system at Setia Alam. It was felt that mapping the approximate locations of groups present within the grid system was important to facilitate other gibbon research. Moreover, the information regarding group size and composition of some of the groups could facilitate monitoring of demographic processes in the future. In addition, the reliability of auditory sampling for the type of terrain typical of this area was tested. Now that its feasibility has been established, further surveys could take place covering a much larger area and could include the other habitat subtypes as outlined above. The effective listening areas of each sample period during this study overlapped, but further studies could place each group of listening posts much

further apart (following O'Brien *et al*., 2004) and providing there were equal numbers of samples representative of each habitat subtype, the data could be extrapolated across a larger percentage of the Sebangau ecosystem to produce more complete population estimates.

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Appendix 1: Data Collection Protocol for Ground Surveys

Protocol for Ground Surveys
Cara Buckley
June 2004

Aims
- To locate gibbon group(s) that were recorded during triangulation
- To obtain data on mean group size and age/class estimation

Basic information
- Ground surveys will take place after each morning of triangulation by the same teams of researchers.

Methods
- At 1000 hours, or if the gibbons have not resumed calling for a period of more than 30 minutes, researchers commence ground surveys
- Both teams track in on the last compass bearing on which they recorded a call
- If a gibbon group is sighted, researchers should stop and record the information on the data sheet. Try to note number of individuals in the group and group composition (male/female, number of adults, sub-adults, adolescents, juveniles and ventral infants, as with sightings during triangulation)
- If the gibbons do not flee upon detection, simple behavioural data should be recorded (see data sheet)
- Walk at a controlled speed of 1 kilometre per hour

Notes
- Try to be quiet when moving through the forest and keep talking to a minimum
- If the gibbon group has not seen you, make attempts to remain concealed
- Do not attempt to follow the gibbon group if they become agitated

Appendix 2: Data Collection Protocol for Triangulation

Protocol for Triangulation
Cara Buckley
June 2004

Aims

- To map gibbon calls by recording the compass bearing from researcher to gibbon and approximate distance
- Mapping will indicate number of groups and approximate range

Basic Information

- Researchers need to be in position by 0430 hours and will record calls from that time onwards, until 1000 hours or after a period of no calling, which exceeds 30 minutes. Triangulation requires three teams of researchers positioned at listening posts stationed between 300 and 600 metres apart

Methods

- Teams should synchronise watches to the nearest second prior to departure from base camp
- When a call is heard, start stopwatch immediately to record duration of call
- Note the time that the call starts and ends
- Take a new bearing to each group calling at intervals of three minutes
- The call is deemed to have ended if the gibbons are silent for more than two minutes. Subsequent singing should then be recorded as a new call and a new compass bearing should be taken.
- Record all calls heard, but try to note type of call: duet or solo
- Take a compass bearing from researcher to the location of calling group
- Estimate the distance from researcher to calling group (in metres)
- If sightings occur while at listening post, record these on the data sheet: time of sighting, number of animals, age and class estimation (I=infant, J=juvenile, AD=adolescent, S=sub adult and A=adult (see sheet), direction of travel
- Weather has been shown to have an effect on singing frequency. Thus, one researcher needs to record the weather at ten-minute intervals on the appropriate data sheet, categories include cloud cover (>50%/<50%), S=sunny, R/NR=rain/no rain, C=calm, B=breezy or W=windy.

Notes

- Sit quietly at the listening post and keep talking to a minimum
- Do not attempt to imitate gibbon vocalisations
- Stay in radio contact with the other team, the aim is to record the SAME gibbon group

Appendix 3: Triangulation Data Sheet

Date: Listening post no: Researchers: No./Name of GPS Waypoint(s)

Time	Group 1	Group 2	Group 3	Group 4	Group 5
0430					
0433					
0446					
0449					
0452					
0455					
0458					
0551					
0504					
0507					
0510					
0513					
0516					
0519					
0522					
0525					
0528					
0531					
0534					
0537					

Appendix 4: Weather Data Sheet

Date: Time: Post No: Name:

Weather	
Cloud cover: **Clear <50%/>50%** **S**unny **R**ain/**N**o rain **C**alm/**B**reezy/**W**indy	
0530	0820
0540	0830
0550	0840
0600	0850
0610	0900
0620	0910
0630	0920
0640	0930
0650	0940
0700	0950
0710	1000
0720	1010
0730	1020
0740	1030
0750	1040
0800	1050
0810	1100

Appendix 5: Ground Survey Data Sheets

Date: **Researcher:** **Start time:** **Route walked**

Time of sighting	Transect Name	Position along transect & GPS coordinate	Species	No. of animals	Age and class estimation

Animal observer distance	Animal observer angle	Perpendicular distance	Height of animal	CBH of tree	Behaviour (travel, feed, forage, rest, sing)

Appendix 6: Sightings Data Sheet

Date: Researchers: Listening Post Number:

Time of sighting	No. of animals	Age and class estimation *	Direction of travel

*   **M**ale or **F**emale
      Infant, **J**uvenile, **Ad**olescent, **S**ub adult, **A**dult

Appendix 7:   Probability of Calling

Sample period 1

Date	G17	G13	G16	G15	G12	Daily probability of calling
01/07	✓		✓	✓	✓	0.8
02/07	✓	✓	✓	✓	✓	1.0
03/07	✓	✓	✓	✓		0.8
04/07	✓	✓		✓	✓	0.8
Total calls per group	4	3	3	4	3	

By day 2 all groups were heard

Sample period 2

Date	G6	G5	G9	G13	G10	Daily probability of calling
06/07			✓	✓		0.4
07/07	✓	✓		✓	✓	0.8
09/07	✓	✓				0.4
10/07	✓	✓	✓			0.6
Total calls per group	3	3	2	2	1	

By day 2 all groups were heard

Sample period 3

Date	G2	G9	G3	G7	G8	G1	G5	G18	Daily probability of calling
12/07	✓	✓	✓		✓			✓	0.625
13/07		✓		✓	✓				0.375
14/07	✓	✓				✓	✓	✓	0.625
15/07	✓	✓		✓	✓	✓	✓		0.75
Total calls per group	3	4	1	2	3	2	2	2	

By day 3 all groups were heard

Sample period 4

Date	G10	G8	G19	G14	G9	G12	G4	Daily probability of calling
19/07	✓	✓	✓	✓				0.57
20/07					✓	✓		0.29
21/07	✓			✓	✓		✓	0.57
22/07	✓	✓		✓		✓	✓	0.71
Total calls per group	3	2	1	3	2	2	2	

By day 3 all groups were heard

Sample period 5

Date	G14	G19	G15	G13	G11	G9	G7	Daily probability of calling
24/07	✓		✓	✓	✓			0.57
25/07		✓			✓	✓	✓	0.57
26/07		✓		✓	✓			0.43
27/07	✓	✓		✓	✓	✓		0.71
Total calls per group	2	3	1	3	4	2	1	

By day 2 all groups were heard

Probability of calling on any given day during the twenty day research period:

0.62 (±0.18, n=20)

	Probability of calling by Day 1	Probability of calling by Day 2	Probability of calling by Day 3
Sample period 1	0.80	1.00	1.00
Sample period 2	0.40	1.00	1.00
Sample period 3	0.63	0.75	1.00
Sample period 4	0.57	0.86	1.00
Sample period 5	0.57	1.00	1.00
Average	**0.59**	**0.92**	**1.00**
Standard deviation	±0.14	±0.11	0