Using morning duets to survey a population of *Hylobates agilis albibarbis* in the Sebangau National Park: results compared to those found during an initial survey by Buckley (2004).

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Photograph from Harrison et al. (2005)

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Abstract

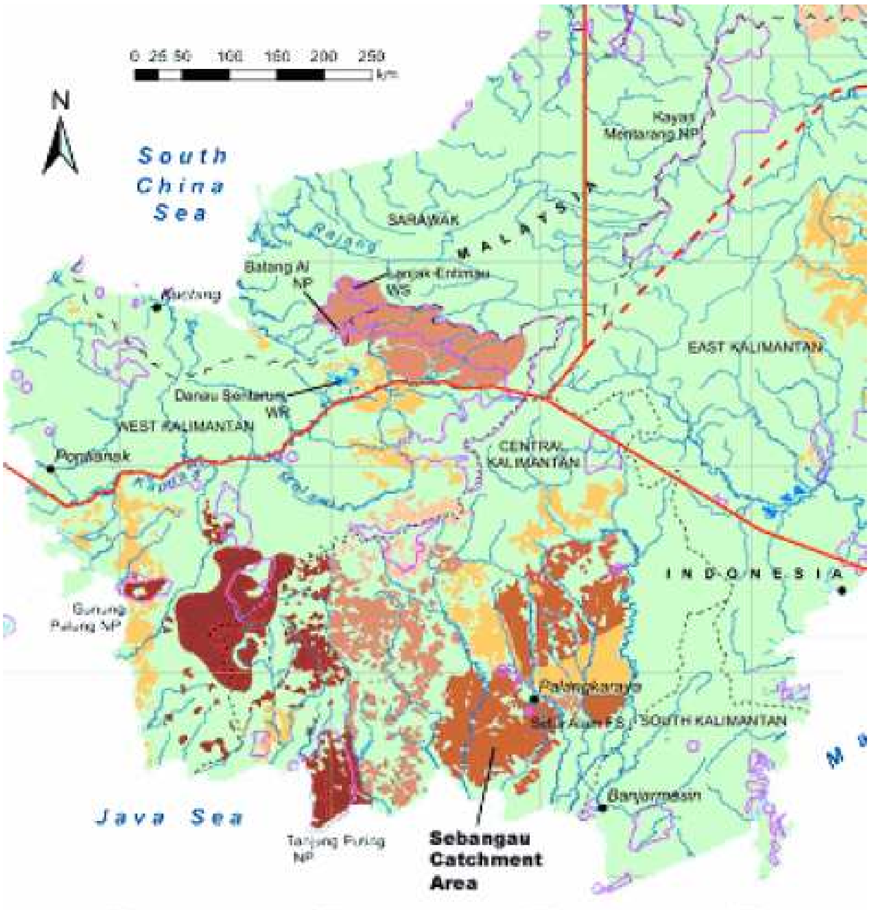
The Sebangau catchment is a newly designated National Park in Central Kalimantan, Indonesia. The area contains a large population of an endemic subspecies of agile gibbon *Hylobates agilis albibarbis*. The first population survey of Sebangau gibbons was carried out by Buckley (2004) by using auditory sampling methods. The aim of this study was to resurvey the gibbon population and to compare the results with those found by Buckley (2004). The method of surveying the gibbons were essentially the same in both studies but each area was surveyed at least twice as long in this study. The study took place between 3 July and 3 November 2005. Listening posts were positioned within a 2 km^2 grid square in the mixed swamp forest, one of the 3 major habitat subtypes. Listening posts recorded data in the form of estimated bearings and distances from the post to the group of vocalizing gibbons.

Triangulation of bearings taken at the same time from different listening posts was used to estimate the position of the calling gibbons. Spatial distributions of estimated calling positions were used to map gibbon territories. This survey detected 15 groups of gibbons. Density analysis generated the following results: densities of 1.64 groups/km^2 and 6.65 individuals/km^2. Extrapolation of the density estimates produced a population estimate of 17500 gibbons within the mixed swamp forest, which is an area of 2622 km^2. These results are slightly lower than those found by Buckley (2004). These differences could be the result of a population decline or simply due to sampling errors. Regardless of which estimate is closer to the true number of gibbons, this population is of huge conservation importance. The results of this study will be used to form the basis of a long-term monitoring program of this population.

Introduction

Borneo is the third largest island in the world. Much of Borneo is still covered by lowland evergreen rainforest, which is concentrated in the four Indonesian provinces that make up Kalimantan. The tall dipterocarp rainforests of Kalimantan are some of the most diverse ecosystems in the world (Nijman 2005). Forests currently occupy around 50% of the land in Kalimantan with most major urban areas situated near the coast. The level of forest coverage is constantly declining. This is a result of massive amounts of logging (predominantly illegal) and huge forest fires that are becoming more frequent. Forest is also removed to convert land for agriculture. At present, palm oil plantations pose a huge threat to the survival of Indonesian rainforests (Nijman 2005).

Figure 1.1: Map of Borneo showing the study site Sebangau catchment area from (Buckley 2004)



Borneo has a very rich primate fauna. There are 14 different species and two thirds of them are found nowhere else (Nijman 2005). There are 3 species of ape; these are the Orang-utan (*Pongo pygmaeus*), the Müller's Gibbon (*Hylobates muelleri*) and an endemic agile gibbon sub-species (*Hylobates agilis albibarbis*). The list also includes several macaque and leaf monkey species, the proboscis monkey, the slow loris and the western tarsier. The majority of Borneo’s primates are restricted to rainforest habitats thus directly threatened by deforestation (Nijman 2005).

Gibbons belong to the family Hylobatidae, which has a wide distribution all over the rainforests of Southeast Asia. Apart from habitat destruction, hunting is the most significant threat to gibbons. In Borneo there is a thriving pet trade in infant gibbons. To capture the infants, hunters must kill their mothers first. Infant gibbons are frequently killed as they fall out of the tree when their mother is shot. Gibbon meat has traditionally provided a source of protein to the indigenous people from the interior of Kalimantan. However, the main motivation for hunting gibbons at present is the high price they command as pets. There is also an international trade in gibbon products for traditional Chinese medicine (Nijman 2005).

The range of agile gibbons comprises areas of Borneo, Sumatra, Peninsular Malaysia and Thailand. Bornean agile gibbons are only found in west and central Kalimantan between the Kapuas and Barito rivers. Although Bornean agile gibbons are classified as a sub-species of agile gibbon there is evidence to suggest that they should be recognized as a separate species. Significant differences in genes, morphology and vocal characteristics support the conclusion that the Bornean agile gibbon signifies a distinctive evolutionary unit (Nijman 2005). The IUCN has evaluated the status of the

Bornean agile gibbon in the same threat category as the agile gibbon. Agile gibbons are classified as LR/nt by the IUCN, this means they are in the lower risk category but they are close to becoming vulnerable (IUCN 2004).

A study by Mitani (1990) on the demography of agile gibbons in west Kalimantan examines the factors that make gibbon populations less able to recover from declines. Gibbons, and apes in general, are more vulnerable than other primate species because they have unusual life history characteristics. The inter-birth interval is particularly long in gibbon species (3.2 years) relative to other primates of a similar size (Mitani 1990). The two behavioural factors that influence the composition and spacing of gibbon groups are territoriality and monogamy. The existence of exclusive territories imposes restrictions on population density. The establishment of stable monogamous family groups reduces the mortality in the infant and juvenile stages. However, the formation of new gibbon groups in saturated habitats is rare, this means that sub-adults undergoing dispersal have very high mortality. The long life span of adults and high sub-adult mortality leads to a top-heavy age-class pyramid. This situation does not favour population growth (Mitani 1990).

Accurate estimates of population size are crucial for the conservation of threatened species. The most suitable technique for sampling a population is determined by examining the behaviour and ecology of the study species. Once a suitable technique has been found, it is necessary to repeat the survey as frequently as possible to track changes in the population density and occupied areas. Successful conservation requires up to date information to make informed decisions on the best conservation strategies. Forest primates are notoriously difficult to survey, (Brockelman and Ali, 1987). If the primates are not habituated, sightings can be very infrequent so methods that do not rely on sightings must be found. Orang-utans have been successfully surveyed by counting the nests that they make every night. Ongoing population surveys in the Sebangau peat swamp forest of central Kalimantan have led to the discovery of the world's largest continuous population of orang-utans (Morrogh-Bernard et al. 2003)

Auditory sampling methods are suitable for primates that perform loud calls at regular intervals that are audible over large distances (Brockelman and Ali, 1987). Primates such as gibbons and indris meet these criteria well (Johns 1985). Guidelines for using loud calls to sample primate populations were developed by Brockelman and Ali (1987), and are still in use today. Brockelman and Ali (1987) recognised that line transect methods of sampling gibbons were producing underestimates of population density because gibbons are so difficult to detect.

Auditory sampling works so well for gibbon species because mated pairs perform easily recognisable duets. Gibbon group sizes are fairly stable and territories are essentially exclusive. Mapping the estimated location of these duets gives a good indication of the position of the gibbon groups. If researchers listen from separate locations in the forest, triangulation can be used to gain a more accurate estimate of the group's location. Triangulation takes the point of intersection between the two estimated bearings as the gibbon group's location (Brockelman and Ali, 1987).

When estimating group densities by auditory sampling it is assumed that all gibbon groups will be heard. If this is not the case then a correction factor must be used (Brockelman and Srikosamatara 1993). Density and weather both affect calling frequency, which can complicate the calculation of the correction factor. Gibbon populations that are at lower densities may be under-estimated by auditory sampling, because territorial calling is not as necessary in dispersed populations (Brockelman and Ali 1987).

A comparison of sampling techniques was done using two populations of Muller's gibbons in east Kalimantan by Nijman (2001). Three techniques were used: range mapping, line transects and fixed point counts following the methods of Brockelman and Ali (1987). Nijman (2001) found that the three techniques produced significantly different results. Nijman (2001) advises caution when comparing density estimates obtained using different techniques.

Buckley (2004) used auditory sampling methods to survey a population of *Hylobates agilis albibarbis* in the Sebangau catchment of central Kalimantan. The study was the first population survey of this subspecies. The study was done to compliment the existing work on Sebangau orang-utans by Morrogh-Bernard et al. (2003). Shortly after the completion of this survey, the Sebangau was designated a National Park, predominantly due to the area containing the largest known population of orang-utans (Morrogh-Bernard et al. 2003). Although the study by Buckley (2004) was only short, the results indicated that the Sebangau catchment might also contain the largest population of *Hylobates agilis albibarbis.*

Auditory sampling by Buckley (2004) in a $2km^2$ grid of Sebangau peat swamp forest detected 19 gibbon groups. The average group size based on sightings was 3.4 individuals. The calculated density of the area was 2.2 groups (7.4 individuals) per km^2. Extrapolation of these results yielded a population of 5700 within the mixed swamp forest subtype. Buckley (2004) did not survey the other habitat subtypes. It is likely that gibbon densities follow a similar pattern to those of orang-utans because they rely on the same resources. If this is the case then the density in the low pole subtype will be significantly lower and the density in the tall pole subtype will be significantly higher (Morrogh-Bernard et al. 2003).

The aim of this study was to carry out a second population survey of the gibbons in the Sebangau catchment. The purpose of the resurvey was to find out if there had been any fluctuations in the population in the year since Buckley (2004) completed the initial survey. It was also felt that the sample period of the preliminary survey by Buckley (2004) might be too short to permit reliable conclusions. The sample period for this study was over twice as long as that of Buckley (2004). The future of the Sebangau gibbons is looking more hopeful since the area acquired the status of a National Park and should receive satisfactory protection. If all goes well I would expect gibbon numbers to increase in this area. However, this is not always the case. If proper measures are not taken to stop illegal logging and hunting the population may even decline.

Methods

Study site

This study took place within the Sebangau catchment of Central Kalimantan. The Sebangau catchment is a 9200 km^2 area of peat swamp forest that lies between the Katingan River to the west and the Kahayan River to the east. There are 3 major forest sub-types in the catchment. On the perimeter of the peat dome there is mixed swamp forest, which extends 6 km into the interior. This forest has an intermediate canopy height and relatively high biotic diversity. Beyond the mixed swamp forest is low pole forest, where there are fewer species and the canopy is lower. Low pole forest is found for a further 7 km. At the summit of the peat dome there is forest consisting of multiple strata growing on thick peat. This is the tall interior forest. The species abundance and diversity of the tall interior forest is much greater (Morrogh-Bernard, Husson et al. 2003). In 2004 5700 Km^2 of Sebangau catchment was designated as a National Park (WWF Indonesia).

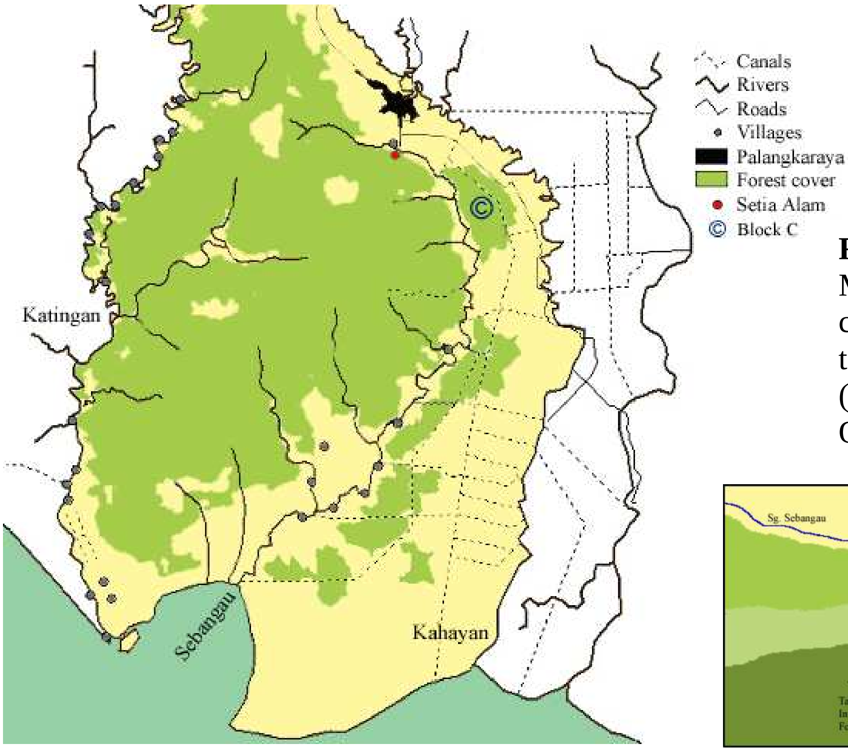
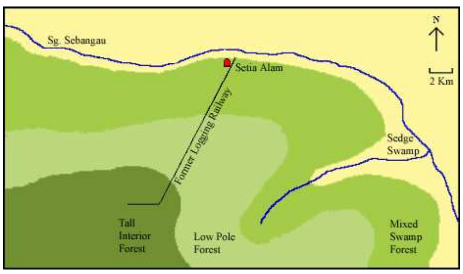


Figure 2.1:
Map of the Sebangau catchment showing the three forest subtypes (maps donated by Outrop)



Research was carried out from the Setia Alam field station, which is the base camp for the Orang-utan Tropical Peatland Project, (OuTrop) and the centre for International Cooperation in Management of Tropical Peatland (CIMTROP). Setia Alam is situated 20 km Southwest of Palangka Raya, which is the provincial capital of Central Kalimantan. The field station was formerly the headquarters for a logging concession and lies on the edge of the forest roughly 1 km from the Sebangau river. Between the river and the field station the forest was logged and is now covered in sedge swamp.

Setia Alam is at the Northeast corner of a 3 km^2 grid square. The grid square is divided by 13 major transects vertically and 12 horizontally. Each transect is marked every 25 metres. The eastern boundary of the grid system is a disused railway line, which was built by loggers. The grid is within the mixed swamp forest sub-type. All data collection took place in a 2 km^2 within this grid system.

<u>Procedure</u>

Data collection took place between 3 July and 7 September and 1- 3 November 2005. Data was collected from 5 separate areas within the 2 km^2 grid system. Each site was surveyed for 5 consecutive days initially. This was repeated in all but one of the areas. When surveying the area that was the furthest away from base camp it was necessary to camp there for 5 nights, as it was too far to walk in the morning. It was not possible to repeat this during the summer because as the dry season progressed the water in the canal dried up and left the campsite with no water supply. In November the water level was sufficient to allow a repeat survey of this area for 3 days. Data collection took place on 48 days altogether.

Each area had three listening posts, Brockelman, and Ali (1987) recommended spacing of 300-600m between listening posts. The lower end of this range was used in this experiment following the rational of Buckley (2004) that gibbon calls do not carry as far over level forest terrain like this study area. Two researchers were positioned at each listening post and they were ready to start recording gibbon calls at 4:30 am. Before departing from base camp, each team of researchers was given a hand-held radio and digital watches were synchronised.

When the gibbons started to call, which usually occurred before 5 am except in unfavourable weather conditions, the direction and distance were recorded on a data sheet, (see Appendix 1). A compass was used to determine the direction. A rough distance estimate was made based on the volume of the call. Accuracy improved with practice but distances were not very important when using a triangulation method. The distance and direction were recorded for all groups that were heard singing within 3-minute intervals.

Several factors were used to distinguish between different gibbon groups. The bearing was enough if the calls were from completely different directions, but if it was suspected that there were multiple groups in roughly the same direction then the estimated distance became important. Also if multiple groups could be heard singing at the same time, the separate groups could be distinguished. If a group was silent for a while and then more calls were heard later from a similar direction and distance, it would be presumed that this was the same gibbon group.

Notes on whether the vocalisations were solo or duet/group calls were taken. Only male agile gibbons produce solo calls (Geissmann 2000). Duets include codas by the males and great calls by the females. Great calls are the least variable and most conspicuous part of the duet (Haimoff and Gittins 1985). It was easy to record which groups were great calling in the 3-minute intervals. This was very helpful for group identification when carrying out the triangulation.

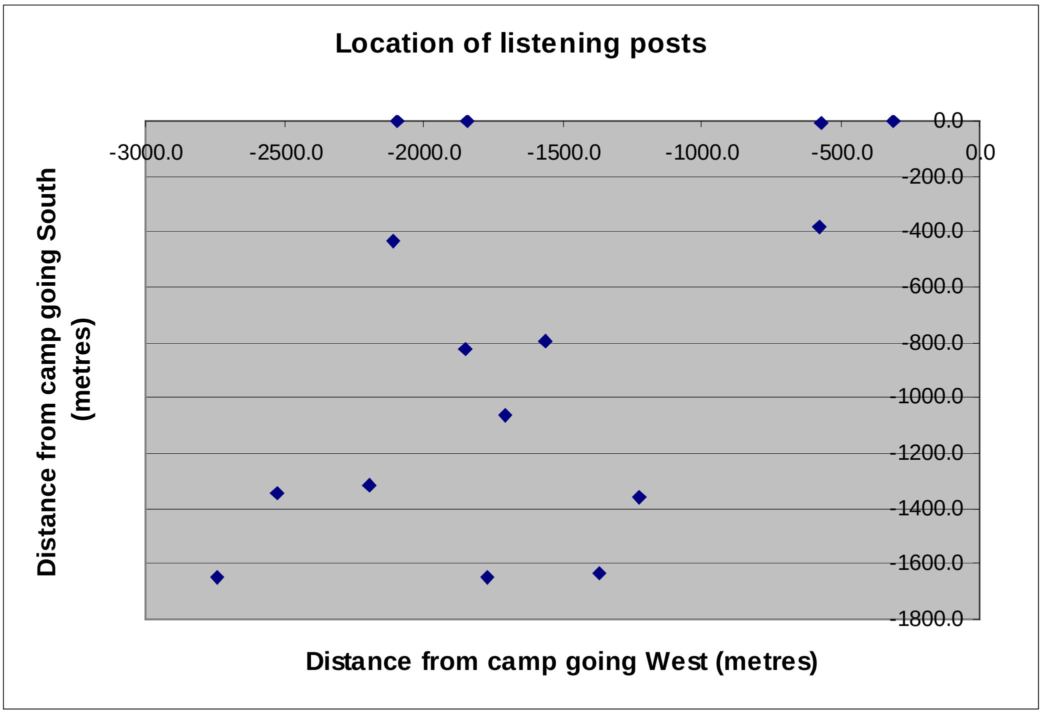
According to Brockelman, and Ali (1987), weather affects singing frequency in all studied species of gibbon. In particular, wind and rain are known to suppress gibbon vocalizations. The weather was recorded at 10-minute intervals on a data sheet, (see Appendix 2). Researchers noted if it was raining, if the air was calm, breezy or windy if it was sunny and if there was more or less than 50% cloud or clear sky. As each area was surveyed for 10 days there was no need to repeat bad weather days. In shorter studies weather affects the probability that all gibbon groups will call in the sample period so days of unfavourable weather must not be included (Brockelman, and Ali 1987). Rainwater was collected and measured every morning and afternoon at the field station. Weather was recorded for this study to examine the relationship between weather conditions and singing frequency.

If sightings occurred whilst researchers were at the listening post, they were recorded on a data sheet, which included time of sighting, number of animals, age class estimation (infant, juvenile, adolescent, sub-adult and adult, see Appendix 3). Also direction of travel was noted. Gibbons were not followed during the listening period and noise was kept to a minimum so that the gibbons did not make any alarm calls due to human disturbance.

The period of listening ended after 30 minutes had gone by and no gibbons had been heard by any of the researchers. This was established by radio communication. If the gibbons had not finished calling by 10 am then data collection was abandoned. It is unlikely that gibbons will be giving territorial calls at this time of day, unless there has been a lot of rain during the morning.

GPS readings were taken for each of the listening posts and base camp; this enabled us to calculate where the posts were in relation to base camp and each other. The coordinates of each post are plotted in Figure 2.2.

Figure 2.2: Map shows the positions of 5 groups of 3 listening posts in relation to each other and base camp. Base camp located at 0,0.



Searching for gibbons

We searched for gibbons on at least 3 days in every 5-day period. Searching involved following a route on transects in a zigzag pattern. Two teams went searching and each would take a complimentary zigzag so that the same area was being covered at the same time and nothing was missed out. The search teams were both led by a person who was experienced in the forest. They walked slowly and quietly and stopped at regular intervals, to listen for any movement in the trees. This was very challenging on windy days because of the noise produced by wind in the canopy.

When a sighting occurred researchers stayed as still as possible and wrote down all the details they could gather. Attempts were made to follow gibbon groups to get additional information. This was very difficult as the gibbons were not habituated and moved very quickly through the trees. Usually the gibbons issued alarm calls when disturbed by humans.

The purpose of collecting sightings data was to calculate the mean group size to use in the final density estimate. During the past year field assistants have recorded all gibbon sightings in the grid system. This has produced a large amount of data from which the mean group size has been calculated.

Methods of analysing the raw data

Locating the gibbons

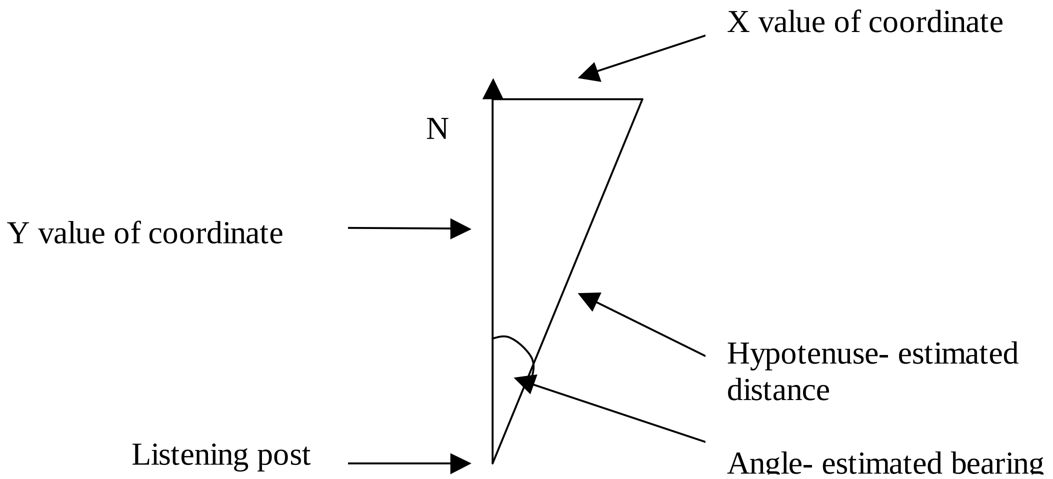
It was possible to locate the position of a group of vocalizing gibbons when compass bearings taken at the same time from 2 or more teams of researchers intersected. The position where the lines cross gives a good estimate of where the gibbons were at that time. When all 3 teams heard the same group of gibbons, the lines did not always meet in exactly the same position. Slight errors in the angle estimation can lead to either a triangular area between the lines or 2 lines that run parallel and both bisect the third line, (see figure 3.4).

In these cases the average point was taken by calculating the mean of both the x and y coordinates.

When analysing the data it was necessary to extend some of the lines beyond the distance estimate to allow them to cross. This was done because the distance estimates were not reliable. Researchers frequently underestimated distance, as gibbon calls can be heard over larger distances than would be expected from their volume (Brockelman, and Ali 1987). When more than one intersecting observation occurred at the same time from a single listening post, distance estimates were used to choose the best matching observation for triangulation. The timing of the calls and the type of call were also used to distinguish different groups. Great calls confirm the presence of mated pairs because adult females only produce them in the presence of their mate and juveniles will join in with their mothers.

Maps of the estimated locations of calling gibbons were made daily. Buckley (2004) plotted calls onto hand drawn maps. This method was not used for this study because it was inaccurate since the transects of the grid system are not perfectly straight so they cannot be used to measure distance. Trigonometry was used to work out the coordinates of the estimated gibbon groups for each listening post. The bearing and distance are the angle and hypotenuse of the triangle. The opposite and adjacent are the x and y coordinate of the estimated group, (see figure 2.3).

Figure 2.3: Show coordinates of estimated gibbon groups can be determined by trigonometry.



<u>Making the maps</u>

The maps were made using a program called ImageJ. A macro was written for ImageJ, which enabled it to draw lines at the specified angle and distance from each listening post at a given time. Time was the third dimension on the map, each 3-minute interval accounted for one slice of the map stack. This meant that only calls, which happened at the same time, were used to make crosses. Call type was represented in ImageJ by drawing solo calls blue, duet calls green and great calls red. When a cross was made the intersection point was selected and measured. The results from each day were collected and combined with the other days from the same area.

<u>Determining group territories</u>

The '500m rule of thumb' which was proposed by Brockelman and Ali (1987) states that calls which map more than 500m apart must be made by different gibbon groups, this estimate is based on the average length of a group territory. The maps of each area were analysed for clusters using a program called Biotas which was downloaded from the Ecological Software Solutions website (www.ecostats.com). Cluster analysis was done using minimum convex polygons in Home Range Analysis. This function draws outlines around the main clusters of data points dependent upon a user-specified data inclusion percentage. I could then measure the distances between clusters to establish whether they could represent the territories of separate gibbon groups.

The method of recording calls every 3 minutes produced a lot of repeated data (that is series of consecutive calls coming from the same location). These repeats had a strong influence on the clusters. To overcome this influence I looked at the data from each day separately, I took averages of all points that were less than 300m apart. This allowed me to see if gibbons were being heard in the same areas on different days and allowed me to perform a valid statistical test to see if the data was clumped.

Calculating density estimate

The density of gibbon groups in the study area was calculated by dividing the number of groups heard (n) by the effective listening area (E). The effective listening area is calculated by drawing circles with a radius of 1km around all of the listening posts. 1km is the maximum distance that gibbon calls will travel through a level forest (Brockelman, and Ali 1987). Only areas where at least 2 circles overlapped were included in E because the calls had to be audible at 2 or more listening posts for triangulation. The effective listening area was reduced to only include area covered by forest. The listening posts on transect 0 which runs west from base camp were less than 1 km from the edge of the forest. The forest north of Setia Alam was logged and is presently covered in sedge swamp, the inclusion of any of this area in the effective listening area does not make sense as it is not a viable gibbon habitat.

Brockelman and Srikosamatara (1993) recommend using a correction factor when calculation group density from auditory sampling. A correction factor is required if the proportion of gibbons expected to sing in a sample period is less than 1. If this is the case the estimate will need to be multiplied by the correction factor 1/p, where p= the proportion of groups that sing in sample period. For a sample of multiple days (m), $p_{(m)}=1-[1-p_{(1)}]^{m}$. This method avoids underestimation of density in short sample periods. It was not necessary to use the correction factor for the results of this study because the cumulative proportion of groups singing approaches 1 when m equals 5 days and each area was surveyed for 10 days (Cheyne et al (in prep) (see table 2.4).

Table 2.4: Average probability of calling (Cheyne et al (in prep)

Forest sub-type	**Average calling probability total study period (n = number of study days in each forest sub-type)**	**Day 1**	**Day 5**
MSF	0.67 (±0.11, n=50 days)	0.60 (±0.14)	1.00 (±0.12)

Results

The following results were obtained from the auditory sampling of a population of Bornean agile gibbons. Sampling took place for 48 days in 5 areas of a 2 km2 grid system. The data was collected following the guidelines set by Brockelman and Ali (1987). The data has been analysed by triangulating bearings taken by separate listening posts. Gibbon group locations were determined from the spatial distribution of triangulated points. Density was calculated taking into consideration the estimated number of groups, the area that was sampled and the average group size based on sightings. The gibbon population of the mixed swamp forest was estimated by extrapolation of the sample area density estimate.

All bearings (angle and distance from listening post) from each time period (3 minute intervals throughout the entire sample period) were mapped on a 5,000 x 5,000 pixel image to create a three-dimensional data stack (Figure 3.1). From the total data set of 7477 observations (Table 3.2), just over half of the data produced intersections within the study area suitable to use for triangulation. There was a consistent proportion of useful data collected in each area that was surveyed (Table 3.3). Some groups of gibbons were only audible from one listening post, accounting for some of the data that could not be triangulated. The rest of the unusable data resulted from errors in bearing estimation. Depending on the position of the listing posts relative to the calling gibbons, a very slight miss estimation of angle could cause the bearing to run nearly parallel and therefore fail to intersect within the study area.

Gibbon group location points were generated from the triangulation data. The location points were specified at the intersection of two simultaneous bearings or at the average of the coordinates of the intersections between three bearings (see figure 3.4). A total of 1749 gibbon group location points were generated of which about a third were derived from three point intersections (see tables 3.5 and 3.6).

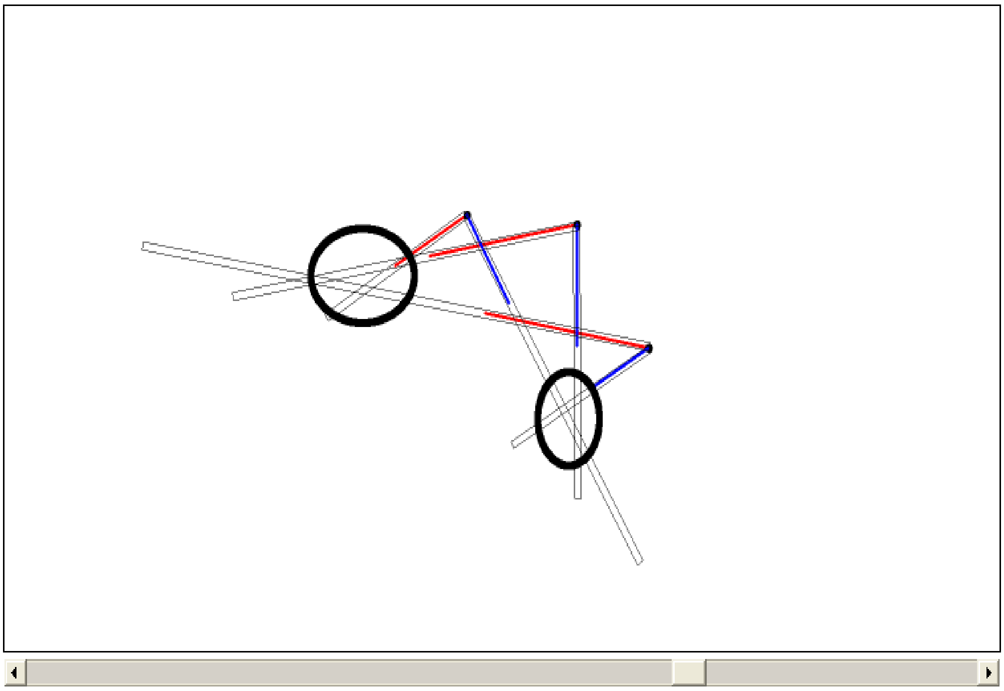


Figure 3.1 Example of a gibbon call data image from a three dimensional stack.

Each bearing consists of a black point indicating the listening post with a coloured line indicating the orientation, distance and type for the call. The line was extended (black and white region) toward the edge of the study area to identify intersections with observations of the same call type from other posts on the same time slice. The bar at the bottom of the window is used to navigate through the time dimension of the stack. The actual data is available as AVI movie files stored on a CD disc

Table 3.2 Total number of bearings taken on 48 sample days

Area 1	1492
Area 2	1135
Area 3	1143
Area 4	1807
Area 5	1900
Total	7477

Table 3.3 Percentage of data used in triangulation

Area 1	51.7
Area 2	51.2
Area 3	53.3
Area 4	52.0
Area 5	52.9
Total	52.3

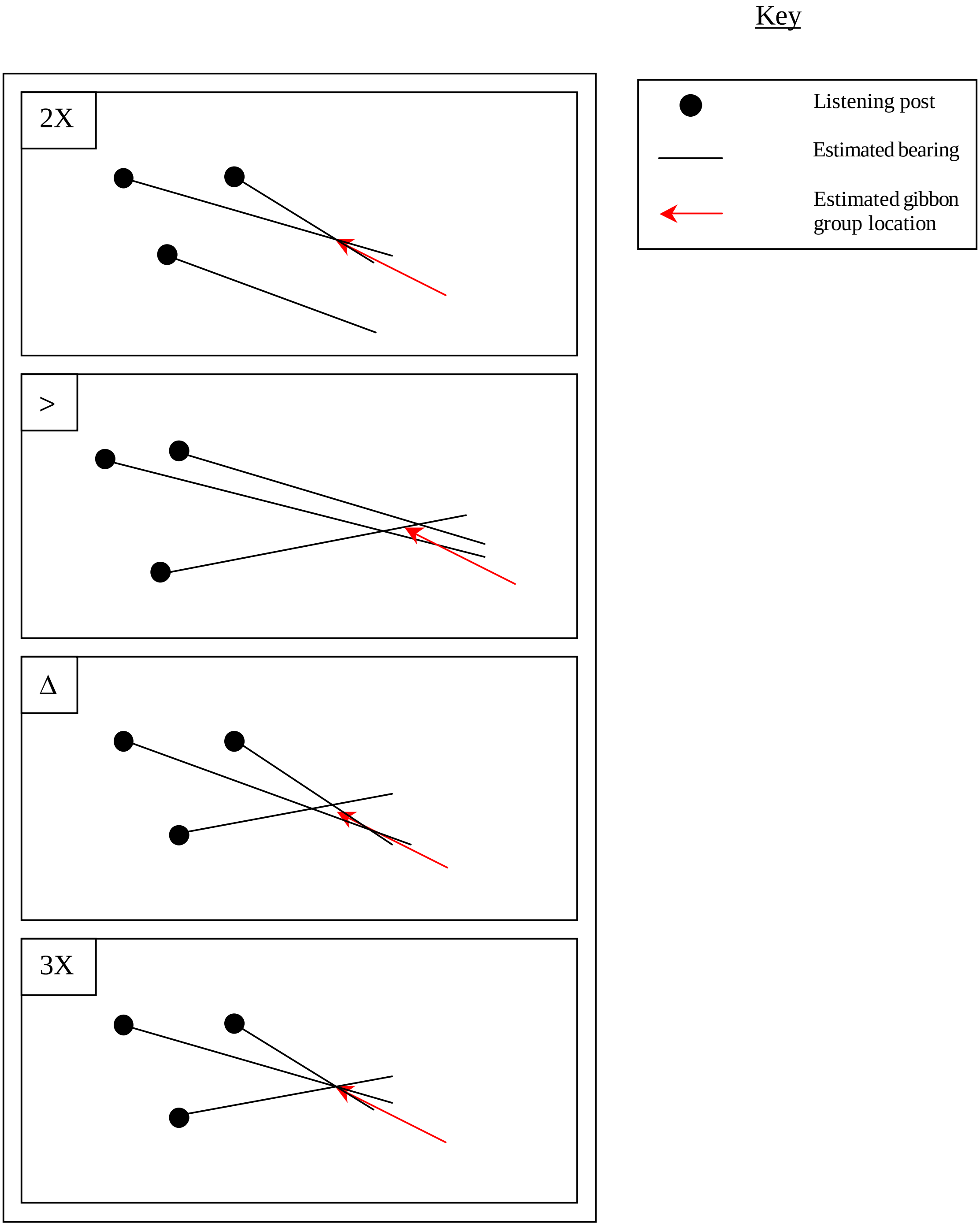


Figure 3.4 Different kinds of intersection used in triangulation.

Table 3.5 Composition of types of intersection

Symbol	% of total data	% of data used in triangulation
2X	35.8	68.4
>	5.0	9.5
Δ	7.1	13.6
3X	4.4	8.4

Table 3.6 Total number of 'gibbon group location' data points

Area 1	343
Area 2	277
Area 3	272
Area 4	413
Area 5	444
Total	1749

<u>Spatial analysis of gibbon group location data points using Biotas</u>

The gibbon group location data points from each area sampled were entered into Biotas separately. The program was used to calculate Minimum Convex Polygons for data points that were aggregated into clusters. All of the repeat data was removed because the program was unable to perform spatial analysis on such large numbers of data points. Removing the repeats made no difference to the appearance of the distribution but reduced the proportion of the points in the polygons (MCP percentage). The MCP percentage was adjusted to identify clusters around 500 m wide, which is the approximate diameter of a gibbon group territory (Brockelman and Ali (1987).

Fig 3.7a shows the distribution of all of the triangulated points from each area. The points from different areas are distinguished by colour. The listening posts are marked by large triangles. Great calls are plotted separately with red triangles to differentiate between clusters of calls that could be attributed to a lone individual and clusters that contain a mated pair. The percentage of data points included for each area was always above 90. This percentage is so high because there was still a lot of similar data collected on the same day even though I removed exact repeats. This method of analysis has produced a lot of small clusters that are quite close together.

It can be assumed that multiple data points in the same area on the same day represent the same group of gibbons because gibbons will only travel a limited distance while vocalising (Brockelman and Ali (1987). For this reason I decided to take the average coordinate of estimated gibbon group locations that mapped less than 300m from each other. I used these daily averages of estimated gibbon group locations to make a new map where clusters of data points represent the positions of gibbons heard on different days (see fig 3.7b). This has taken away the bias introduced by the method of using bearings taken every 3 minutes. This has allowed me to statistically test the distribution to see if it really is clumped (see fig 3.8). When I drew the Minimum Convex Polygons I had to use a lower percentage (70%) because averaging the data caused it to be more dispersed.

Constructing the final map (fig 3.9)

The final map was constructed by referring to both figs 3.7a and 3.7b. The criteria for distinguishing groups was:

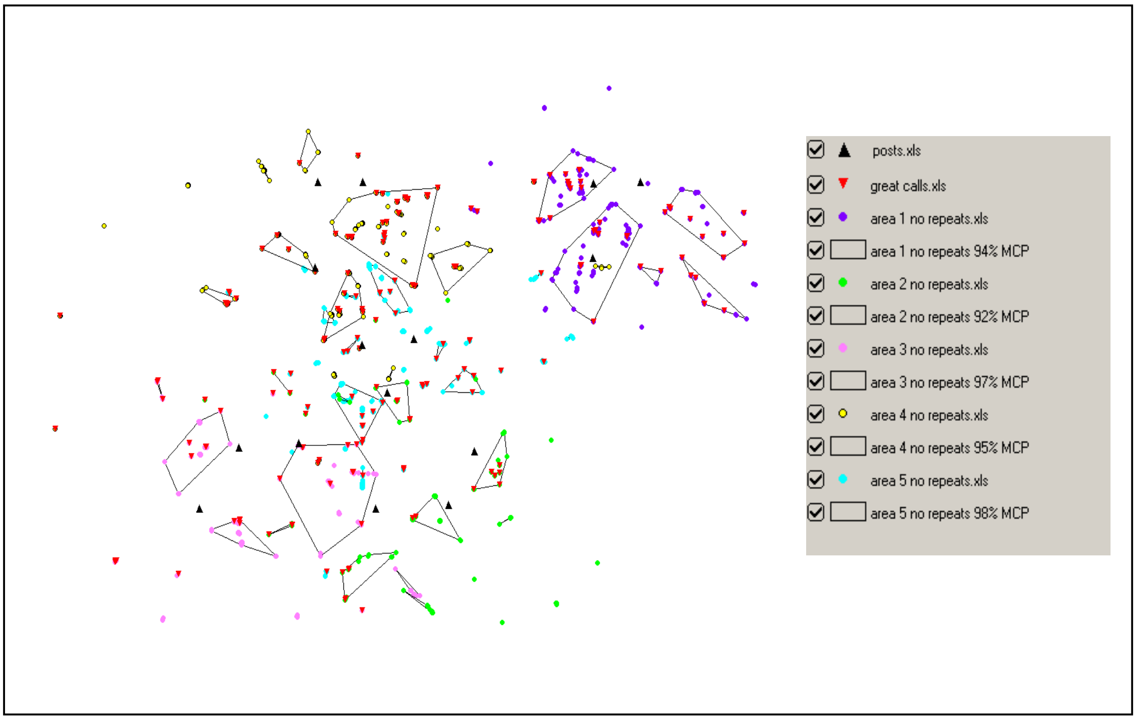
1. Great calls must have been heard within the groups home range (from fig 3.7a)
2. Gibbons must have been heard calling from that area on different days (from 3.7b)

3. Centre of group must be 500m from the centre of nearest group
4. Diameter of group around 500m.

Distances were accurately measured using Biotas then groups were approximately sketched onto a hand-drawn map of the grid system marking all transects. This map was used to allow the gibbon groups' estimated territories to be found by a researcher in the forest and to allow a comparison to be made with the final map of Buckley (2004) (see fig 3.10).

A test was done to see whether the data was clumped. The daily average data was used so that series of data points from the same gibbon group on the same day did not influence the test. If the averaged data points were randomly distributed throughout the grid then they would be expected to fit a random distribution model such as the Poisson distribution. A test of goodness-of-fit to the Poisson distribution was carried out. To make sure the test was fair I chose to test the distribution of points in a 2 Km square in the centre of the effective listening area. The square was divided into 100 200x200m grid squares. The number of points in each grid square was counted (see fig 3.8B). The expected values were calculated with Poisson probabilities. The closeness of fit between the observed with the expected was tested with the $\chi 2$distribution. The total value of $\chi 2$ was compared to the critical value in the table. Using 2 degrees of freedom (4-2) the 1% critical value of $\chi 2$ is 9.21. My test statistic is greater than this so the probability that this distribution would occur by chance is less than 1%.

A



B

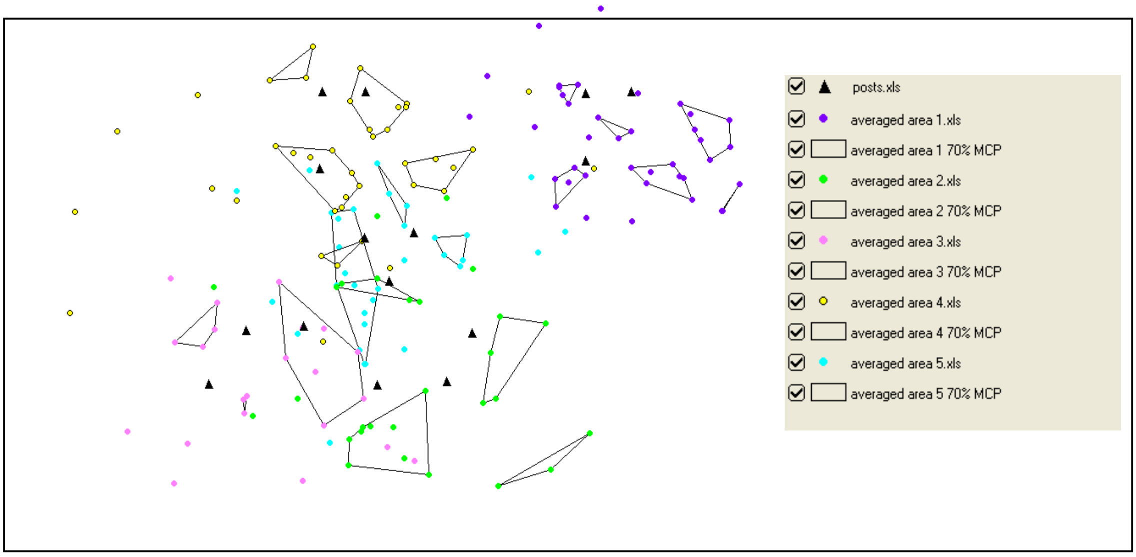
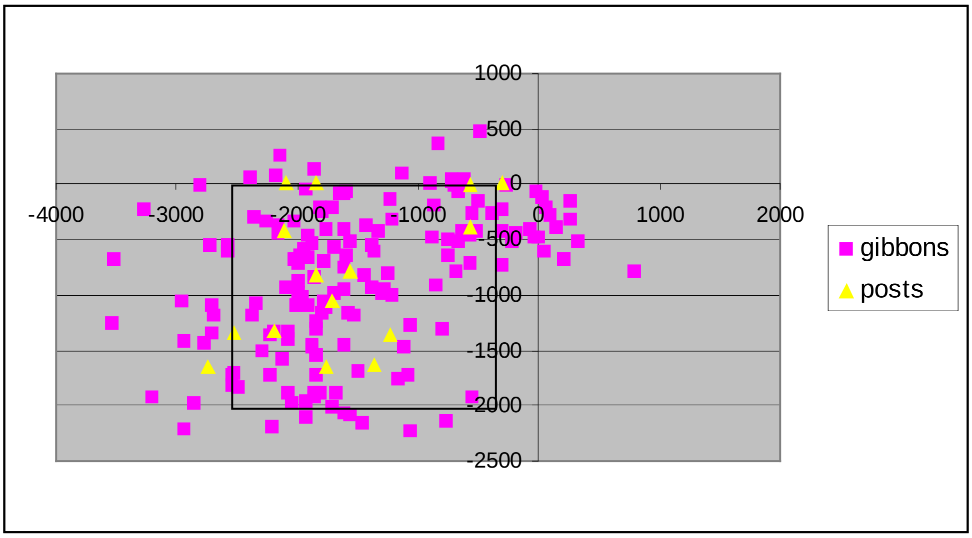


Figure 3.7 Clusters in Minimum Convex Polygon analysis of gibbon group location. (A) Plot of gibbon group locations with duplicate values removed. Gibbon group locations including Great Calls are indicated by red triangles. The clustering was adjusted individually for different areas (see MCP values in symbol definition box). (B) Plot of daily average gibbon group locations. Clustering was analysed at 70% for all areas.

A



Number of points in each grid square as follows:

B

Number of points per square	0	1	2	3	4	5	6
Number of squares	46	26	15	7	2	2	2

C

Number of points per square	Number of squares		Difference	χ2
	Expected	Observed		
0	34.3	46	11.7	3.99
1	36.7	26	10.7	3.12
2	19.64	15	4.6	1.09
≥3	9.4	13	3.7	1.43
				Total= 9.63

Figure 3.8 Poisson analysis of clustering in gibbon group locations (daily-averaged). (A) Distribution of locations over study area including a 2X2Km square where data subset is analysed for clustering by location in a grid of 100 200x200m squares. (B) Frequency table of squares with zero to six locations (C) Expected and observed values for Poisson distribution, difference and Chi squared value for difference.

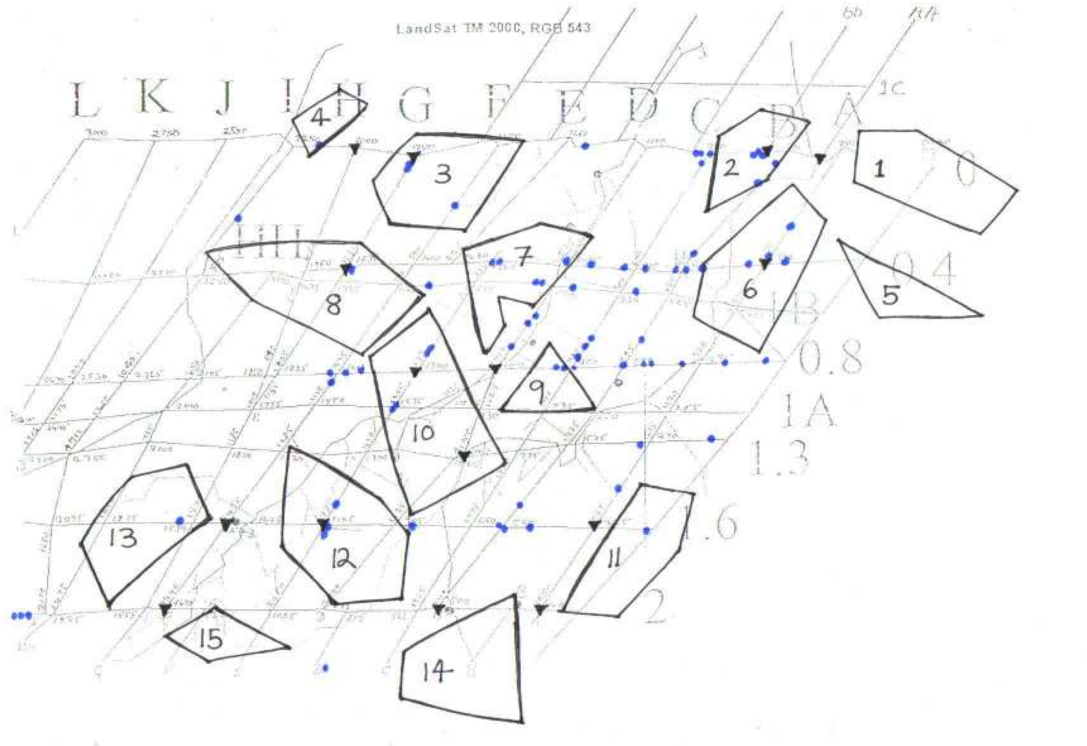


Figure 3.9 Final map of gibbon groups identified by this study
The black outlines represent the minimum territories of the groups numbered 1 to 15. The black triangles represent the listening posts. The blue circles represent the locations of the sightings that were used to gain an estimate of average group size. The large letters and numbers on the axis of the grid identify transects.

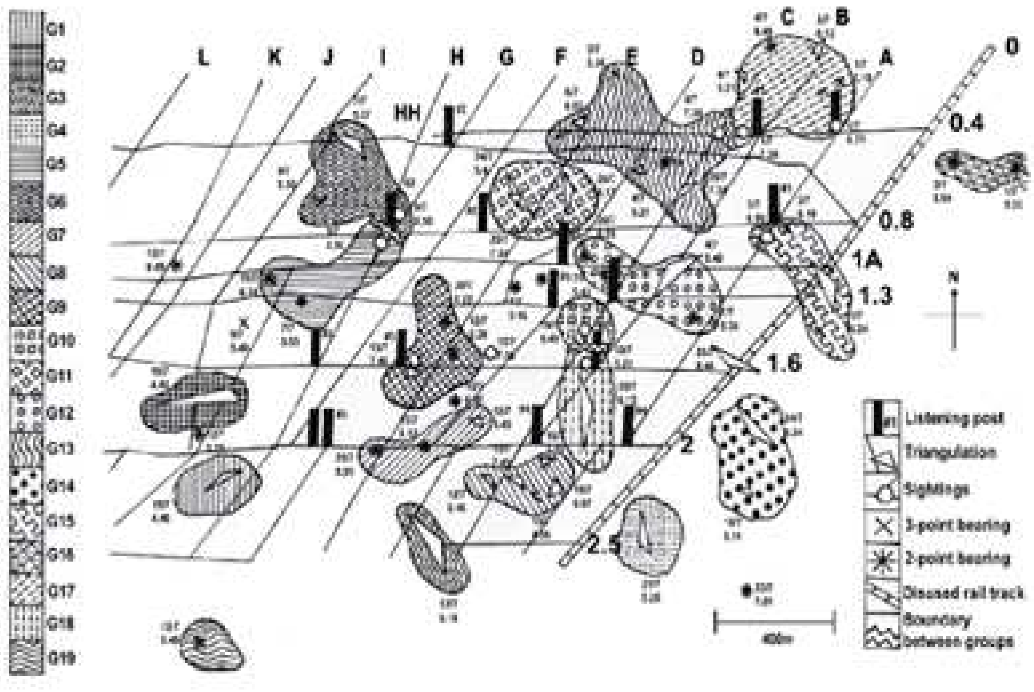


Figure 3.10 Final map of gibbon groups identified by Cara Buckley.
Buckley (2004) identified 19 groups she has given them all a different fill pattern that corresponds to the group number.

Table 3.11 Correspondence of Gibbon Groups between this study with those done the previous year by Cara Buckley

Phillips (2005) Group number	Buckley (2004) Group number
5	16
6	17
7	11
8	6
11	14
13	2
14	8
15	1
Total	8 groups in common

Comparison of maps

When comparing the final maps produced by both studies (figs 3.9 and 3.10) I found that 8 out of 15 or 53% of the groups I identified were found in the same position on the final map of Buckley (2004) (see table 3.11).

Estimation of effective listening area

The effective listening area was defined as the area within a 1 km radius of at least 2 listening posts. This is based on the maximum distance that calls will carry in a level forest (Brockelman and Ali 1987). The combined effective listening area of this study was calculated to be 9.16 km2 (Figure 3.12). All but 3 of the data points (that were averaged daily) are inside the effective listening area. No calls were located beyond the boundary of the forest. The effective listening area is required to calculate the density of gibbon groups from the number heard.

A

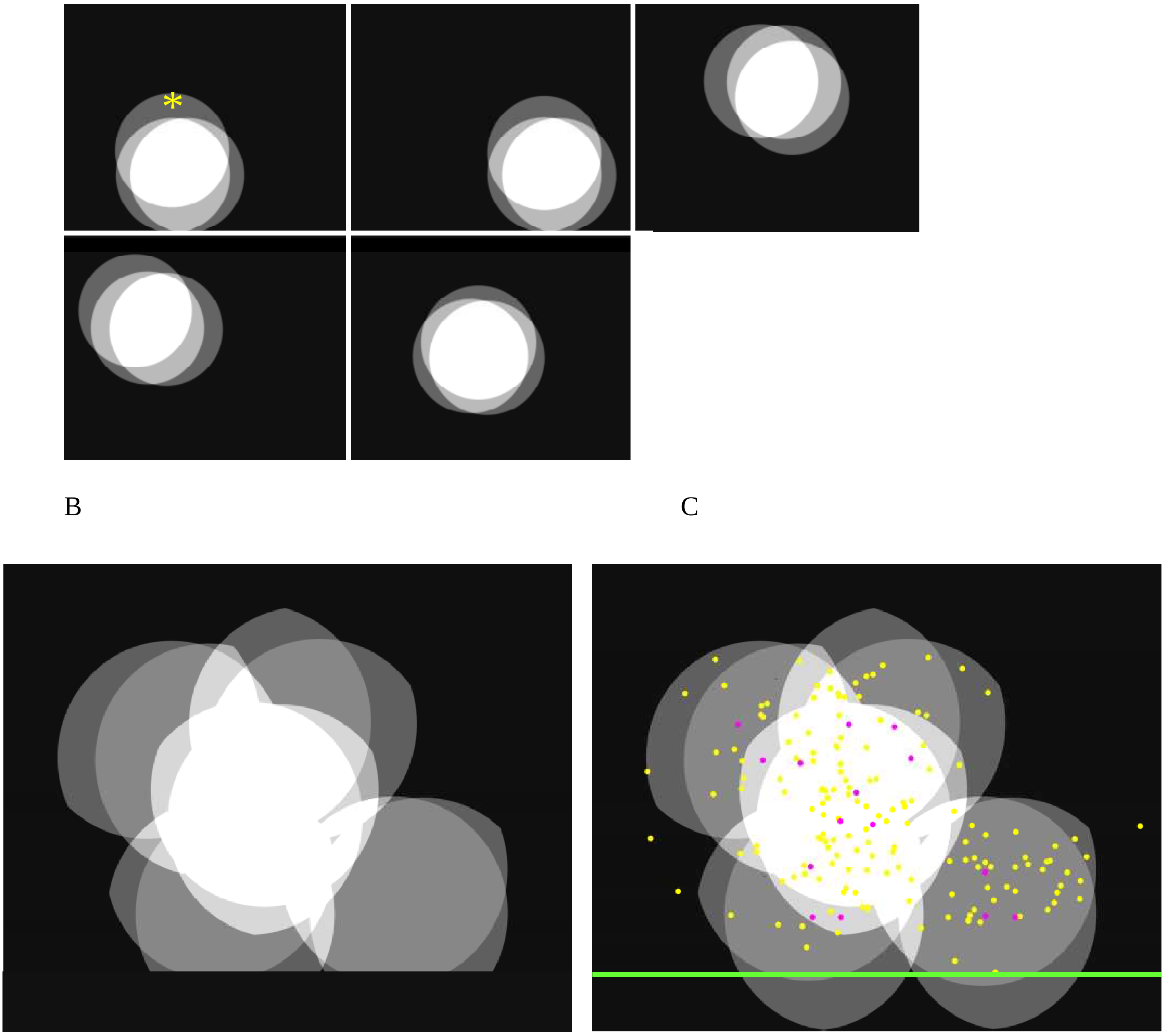


Figure 3.12 Effective listening area for this study. (A) Five regions with three listening posts, each surrounded by one kilometre range mapped on 5000x4000 pixel image (1 pixel = 1 metre). Grey scale intensity indicates overlapping observation areas with black indicating no coverage and dark grey (e.g. marked by yellow asterix) indicating observation from only one post. (B) The dark grey areas were removed and the five areas superimposed to give the combined effective listening area including only areas covered by at least two posts during simultaneous observation. An area of inappropriate habitat beyond the forest border was also removed. The resulting effective listening area (non-black) equals 9.16 km2 (C) Effective listening area with listening posts (pink) and gibbon group locations (yellow) superposed showing boundary of forest (green line).

Average group size was calculated by taking the mean number of gibbons from sightings in the last year.

Average group size = 4.06+/- 0.43 (range 2-5) (see Appendix 4 for sightings sheet)

Density Analysis

Density calculations required the following information: number of groups detected in the effective listening area, the size of the effective listening area and the average group size. The number of groups was estimated to be 15 (see fig 3.9). The average group size was calculated above to be 4.06. The effective listening area was determined to be 9.16km2 (fig 3.12). The gibbon group density equation that was used is:

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

Where: Dg= density of gibbon groups, E= effective listening area and n= number of groups detected in effective listening area. Therefore:

$$Dg = \frac{15}{9.16} = 1.64 \text{groups/km2}$$

Density of individuals

To calculate the density of individuals the group density was multiplied by the average group size.

Di= group density x average group size

Di= 1.64 x 4.06 = 6.65 ndividuals/km2

An estimate of Home Range was made by dividing the effective listening area by the number of groups that were heard in it.

$$\text{Home Range} = \frac{E}{n} = \frac{9.16}{15} = 0.61\text{km}2 \text{ or } 61 \text{ hectares}$$

Extrapolation of density estimate for whole mixed swamp forest

The group density and individual density were both multiplied by the total area of the mixed swamp forest to gain an estimation of population size in this habitat subtype. The area of mixed swamp forest is 2622 km2 (Buckley 2004). The number of groups in mixed swamp forest would equal:

Dg x Area of MSF = 1.64 x 2622 = 4300

The number of gibbons in mixed swamp forest would equal:

Di x Area of MSF = 6.65 x 2622 =17500

These values can be compared to the values calculated in the previous study (see table 3.13). These will be compared further in the discussion.

Table 3.13 Comparison of the overall results of this study with those done the previous year by Cara Buckley.

Result	Phillips (2005)	Buckley (2004)
Average group size	4.06	3.4
Group density	1.64/km2	2.2/km2
Gibbon density	6.65/km2	7.4/km2
Home range	61 hectares	46 hectares
Groups in MSF	4300	5700
Gibbons in MSF	17500	19400

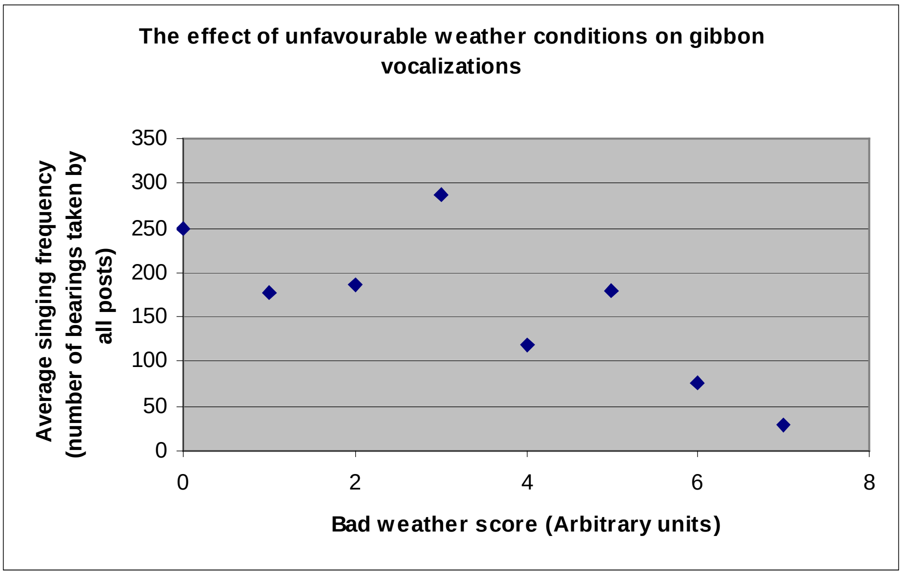
The effect of Weather on singing frequency

Different weather conditions were given a value based on their negative effect on singing frequency (see table 3.14). The extent of cloud, wind and rain was evaluated each day and the score was added up. Over the sample period the score ranged from 0 to 7. For each score, the average singing frequency of all days with that score was calculated and plotted against the score (see fig 3.15A). A measure of morning rainfall collection was also tested for correlation with singing frequency. This measure includes rain that fell in the night and early hours of the morning. For each day the measure of morning rainfall was plotted against singing frequency (see fig 3.15b). The coefficient of correlation was calculated by using Pearson's Product moment correlation formula (see fig 3.15C). Correlation between singing frequency and both weather variables was calculated separately, the results are shown in fig 3.15D. The weather scoring system showed a better correlation than the quantitative measure of rainfall. This will be considered further in the discussion.

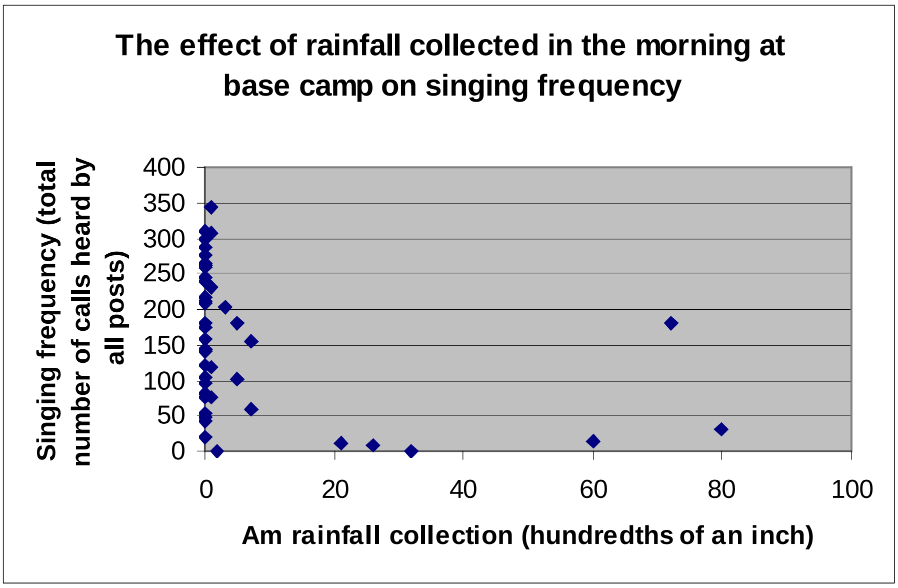
Table 3.14 Weather scoring system

Weather condition	Score
Some cloud	1
Some wind	1
Cloudy	2
Windy	2
Slight rain	3
Heavy dripping	4
Heavy rain	5

A



B



C

Pearson's Product moment correlation

Correlation of coefficient $r = \frac{Sxy}{\sqrt{Sxx\ Syy}}$

D

Variables tested	Correlation of coefficient r
Bad weather score and singing frequency	-0.53
Am rainfall collection and singing frequency	-0.35

Figure 3.15 Correlation of calling frequency with weather parameters. (A) Plot of average singing frequency against 'bad weather' score. (B) Plot of average singing frequency against the base camp morning rainfall collection. (C) Formula used for calculation of Pearson's Product moment correlation. (D) Table of results.

Discussion

The results of this study will provide a baseline of population data and methods for a long-term monitoring program of the Bornean agile gibbons in this area. This program is still in its initial stages. Auditory sampling is the recommended method of sampling gibbon populations (Brockelman and Ali 1987).

Analysis of data quality

Calling can be used to generate spatial distribution data by either triangulation or by polar coordinate (angle and distance estimates). We have taken both kinds of data. Triangulation data depends upon simultaneous observation by at least two different posts. Almost half of the data we collected could not be used for triangulation (see table 3.3) because it was recorded only at one post or the orientation was so inaccurate that there was no intersection. Of the data that was used, only 8.4% produced points where three bearings intersected in the same place, these were considered to represent the most accurate estimations of bearings (see table 3.5). The results indicate that there was quite a high level of error involved in bearing estimation.

As far as I am aware, measures of the accuracy of triangulation have not been published. Therefore I cannot make a comparison. It is likely that there was a relatively high level of error involved in bearing estimation because the study used a lot of researchers with limited experience of listening to gibbon calls and working in the rainforest. This was unavoidable due to the limited availability of trained field staff.

Brockelman and Ali (1987) recommend that researchers should be familiar with the vocalizations and singing patterns of the study species prior to undertaking a census using loud calls. Nijman (2001) states that auditory sampling is suitable for experienced observers only. Observers who took part in the survey by Nijman (2001) were given a 3 week training period to practise the skills required. It was not possible to run a training period due to the time constraints of this study. According to Brockelman and Srikosamatara (1993), calling group positions can be estimated by a single listener within 20% accuracy if the listener has a lot of experience, I presume this refers to a 20% margin of error but the meaning of this statistic is not made clear.

Another issue that could have confused novice researchers is the tendency of juveniles to copy their parents. The calls of juveniles are acoustically simpler and lower amplitude versions of adult calls (Mitani 1990). This could cause listeners to think there were two groups in the same direction but at different distances, which would produce extra bearings that would not cross.

Sometimes tiny errors of angle judgement can mean that bearings do not cross. This depends of the position of the gibbons relative to the listening posts. In cases where gibbon groups were roughly in line with listening posts the intersection point was very sensitive to small changes in angle. When the posts were directly lined up with the gibbon group the bearings only met if the estimation was perfect. Bearings that almost crossed or ran parallel were not included in the results even if the distances agreed. Incidences like these were reasonably common and accounted for a significant portion of the lines that could not be used in triangulation. In cases like these I would recommend taking the middle point between the lines at the estimated distance. This would only work if the observers were competent at distance estimation.

The effect of weather on singing frequency

Singing frequency was found to show some correlation with weather. Bad weather was quantified by assigning an arbitrary score to each unfavourable element based on the negative effect it has on singing frequency. The correlation coefficient, r, was not as high as would be expected if weather were the only factor affecting singing frequency. From casual observations made during this study it appeared that gibbons were more likely to vocalize the longer they have gone without singing. If there was a period of bad weather and few gibbon calls were heard, as soon as the weather cleared up a large amount of vocal activity would follow. Gibbons may even sing in slight rain if there has been a period of heavy rain beforehand. These observations could be confirmed quantitatively and could be used to modify the correlation in future studies.

Correlation between singing frequency and rainfall was tested because rain appears to be the most significant element of bad weather to effect singing frequency. The correlation coefficient was quite low (-0.35). The low correlation could be showing that other weather conditions also influence the singing frequency or it could equally suggest that factors other than weather are also important. It could also be the result of varying rainfall patterns on a very small scale. It was commonly found to be raining in one part of the grid system and not in another. This means that our measures of rainfall at base camp may not accurately represent the rain that fell on gibbon groups in the forest. The rainwater was measured twice a day once in the morning and once in the afternoon. I felt it was more relevant to use the am collection because it represented rain in the night and early hours of the morning when gibbons most frequently sing. It would also contain any rain from the afternoon/evening after the pm collection, which probably wouldn't affect singing frequency the following morning. It would also be interesting to determine the correlation of calling with rainfall at the nearest observation post over 10 minute intervals to see whether there is a better correlation on a finer time scale.

Calculation of density

This study produced a density estimate of 1.64 groups or 6.65 individuals per km2. These figures are lower than those found by Buckley (2004). Even though the average group size calculated from sightings in the last year is higher than that of Buckley (2004), (4.06 compared to 3.4). The main reason why the density estimate of Buckley (2004) is higher is she found 19 groups in the grid and this study found only 15. There are three possible explanations for this difference:

A net disappearance of four gibbon groups from the area.

Buckley (2004) mistakenly counted groups more than once.

This survey missed some of the groups.

It seems unlikely that four groups have disappeared because this area is constantly monitored and the threats to gibbon groups are minimal. It is possible that the increase in average group size led to territory expansions and forced some groups out of the area. If it is true that gibbons in the study area are declining then this is a very worrying sign for the whole population. It is impossible to say which study comes closer to the true number of groups.

On closer inspection of the final maps produced by both studies (fig3.9 and fig3.10), I have identified 8 groups that are in roughly the same position on both maps. Buckley (2004) identified fewer groups on transect 0 and more groups beyond transect 2. This may be explained by the fact that different locations were chosen for some of our listening posts although both these areas should have been included in our effective listening areas. Buckley (2004) split some groups using ‘group encounter’ sightings. These observations of gibbon group interactions allowed her to define additional territory borders. As I did not use this method, it could explain some difference in the resulting number of groups.

A density of less than two gibbon groups/km2 is considered to be low (Brockelman and Srikosamatara 1993). My density of 1.64/km2 falls into this category. This is not surprising considering the quality of the habitat. The mixed swamp forest is situated on the perimeter of the peat dome so it is the most accessible part of the forest. The site has suffered from logging in the recent past (Morrogh-Bernard et al. 2003). Brockelman and Ali (1987) suggest that gibbons at lower densities will call less frequently. This is because gibbon groups that begin calling have been found to stimulate their neighbours to also start calling. Calling is said to be contagious (Brockelman and Ali 1987). This was observed in this study, most groups would begin singing within a few minutes of each other.

The density estimate does not take into consideration the number of lone gibbons in the study area. At present there is not an acceptable way of estimating the floating population (Cheyne et al. in prep). Mitani (1990) reported rarely seeing lone gibbons and concludes that the proportion of sub adults that successfully disperse and form a new groups is small. Unpaired individuals are likely to receive aggression from mated pairs if they intrude into an occupied territory. The chance of finding a vacant territory is greatly reduced in forests where all suitable gibbon habitat is occupied (Mitani 1990). If there was a technique to accurately measure the age of individuals it would be possible to work out population turnover and evaluate the chance of successful dispersion. Unfortunately there is no non-invasive technique available at this time.

Extrapolation of the density estimate

If the density of gibbons in the mixed swamp forest subtype is roughly even, my data indicates a population of 17400 individuals. This is around 2000 less than proposed by Buckley (2004). The assumption that density of gibbons in the mixed swamp forest subtype is uniform may not be valid. Forest nearer to the perimeter will have suffered a greater degree of disturbance. The study site is monitored every day by researchers; this will greatly reduce illegal hunting. Illegal hunting of gibbons may be prevalent elsewhere in the mixed swamp forest. However, extrapolation is the only option when dealing with such vast areas of forest.

To gain a reliable estimate of the entire population of gibbons in the Sebangau catchment, an extensive study of the two remaining habitat subtypes is required. Cheyne et al. (in prep) documents the results of the first survey of the low pole and tall interior forest subtypes. Auditory sampling was carried out in the two subtypes but only for a short time. It is difficult to spend long periods of time in the inaccessible interior forest because the food and equipment must be carried for 12km.

In the dry season, water shortages limit the amount of time that can be spent in the interior.

Cheyne et al. (in prep) found a density of 0.21 groups/km2 in the low pole forest and 3.08 groups/km2 in the tall interior forest. This follows the same trend as the orang-utan densities surveyed by Morrogh-Bernard et al. (2003). Extrapolation of the density estimates gave a population estimate for each habitat subtype. The total population of Hylobates agilis albibarbis in the Sebangau National Park was estimated to be around 30,000 individuals, which is thought to be the largest contiguous population of this subspecies (Cheyne et al. in prep). This makes the Sebangau catchment an extremely important area for gibbon conservation.

Future work in the Sebangau National Park

The only way to be sure exactly how many gibbon groups live in the grid system at Setia Alam is to spend long periods of time watching them. Gibbons will only allow people to watch them if they have been habituated. The behaviour team at Setia Alam routinely follows habituated orang-utans. A large amount of data has been taken about the behaviour and ecology of these great apes.

The researchers are currently working towards habituating the 10- 20 groups of gibbons in the grid system at Setia Alam. The goal is to follow habituated gibbon groups all day from sleeping tree to sleeping tree. By following gibbons all day, the team will get to know the home range of the habituated groups. By spending a lot of time observing groups, researchers will learn to recognise groups. Eventually this will lead to a much more reliable estimate of the number of groups in the grid system.

Data taken whilst following gibbons may even explain some unanswered questions such as whether gibbons are always monogamous and whether they have exclusive territories. At this time there are currently three habituated groups in the grid system and data collection has began (Cheyne et al. in prep)

A long-term study of white-handed gibbons Hylobates lar in Khao Yai National Park, Thailand has challenged the traditional views of gibbon social structure. Sommer and Reichard (2000) have found many examples of non-monogamous gibbon groups and overlapping territories. A quarter of the groups in their study area were found to be polyandrous. In this high-density population they observed males dispersing to other groups and forming a multi-male group where both males had access to the female. They also found that a gibbon group's home range often overlapped with up to six of its neighbours. They question the view that the primary function of gibbon duets is territory defence. Sommer and Reichard (2000) propose that gibbon duets are a combination of advertisement by females and males asserting their presence.
If gibbon groupings and territories really are flexible then this calls into question the validity of the method of auditory sampling. There is clearly more research needed in this area to clarify the situation. This can only be achieved by long-term studies and may take many years. There is no reason to assume that all populations and all species of gibbons will behave in the same way. Gibbons in the Sebangau catchment do not occur at such high densities as those in Khao Yai. If the behaviour at Khao Yai results from high densities then territorial flexibility may be less likely in the Sebangau.

To gain both accurate and useful information about gibbon populations I recommend using a non-invasive censusing technique such as auditory sampling combined with habituation of some groups to observe complex interactions. Observation of gibbons may alter their behaviour and will certainly effect interactions between habituated and non-habituated groups. Although there are some considerable problems with the methods of auditory sampling, at this time it is the best survey technique available. As new technologies become available for more reliable non-invasive methods of gibbon detection population surveys will become more accurate and less time consuming. It is vitally important to continue monitoring this highly significant population of Bornean agile gibbons.

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Appendix 1: Data sheet used to record calls heard at each listening post

Date		Post Number		Obs		GPS Waypoint/ Location of listening post			
	Group 1			Group 2			Group 3		
Time	Dir	Dist	Song type	Dir	Dist	Song type	Dir	Dist	Song type
04:30	0	0		0	0		0	0	
04:33	0	0		0	0		0	0	
04:36	0	0		0	0		0	0	
04:39	0	0		0	0		0	0	
04:42	0	0		0	0		0	0	
04:45	0	0		0	0		0	0	
04:48	0	0		0	0		0	0	
04:51	0	0		0	0		0	0	
04:54	0	0		0	0		0	0	
04:57	0	0		0	0		0	0	
05:00	0	0		0	0		0	0	
05:03	0	0		0	0		0	0	
05:06	0	0		0	0		0	0	
05:09	0	0		0	0		0	0	
05:12	0	0		0	0		0	0	
05:15	0	0		0	0		0	0	
05:18	0	0		0	0		0	0	
05:21	0	0		0	0		0	0	
05:24	0	0		0	0		0	0	
05:27	0	0		0	0		0	0	
05:30	0	0		0	0		0	0	
05:33	0	0		0	0		0	0	
05:36	0	0		0	0		0	0	
05:39	0	0		0	0		0	0	
05:42	0	0		0	0		0	0	
05:45	0	0		0	0		0	0	
05:48	0	0		0	0		0	0	
05:51	0	0		0	0		0	0	
05:54	0	0		0	0		0	0	
05:57	0	0		0	0		0	0	
06:00	0	0		0	0		0	0	
06:03	0	0		0	0		0	0	
06:06	0	0		0	0		0	0	
06:09	0	0		0	0		0	0	
06:12	0	0		0	0		0	0	
06:15	0	0		0	0		0	0	
06:18	0	0		0	0		0	0	
06:21	0	0		0	0		0	0	
06:24	0	0		0	0		0	0	
06:27	0	0		0	0		0	0	
06:30	0	0		0	0		0	0	
06:33	0	0		0	0		0	0	

Appendix 2: Data sheet for recording weather

Date		Post Number		Researchers	
Time	**Cloud cover**	**Sun**	**Rain**	**Wind**	
04:30					
04:40					
04:50					
05:00					
05:10					
05:20					
05:30					
05:40					
05:50					
06:00					
06:10					
06:20					
06:30					
06:40					
06:50					
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09:00					
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09:20					
09:30					
09:40					
09:50					
10:00					

Appendix 3: Data sheet for recording sightings

Gibbon Sightings Sheet 2005

Date	Post Number	Researchers	GPS Waypoint/ Location of listening post	
Time of sighting	No. of animals	Age and class estimation	Direction of travel (bearing from listening post)	Notes

Appendix 4: Sightings used to calculate the average group size

Date	Transect	Distance along transect (m)	Time first sighting	Time last sighting	Number of animals
27/11/2004	D	700	10:23	10:28	5
28/11/2004	0.8	1625	12:00	12:07	5
28/11/2004	D	900	11:27	11:23	5
29/11/2004	0.8	200	06:03	06:18	4
29/11/2004	HH	300	08:23	08:40	5
30/11/2004	0.4	1000	09:30	09:37	4
05/12/2004	B	500	09:21	09:27	5
07/12/2004	1.3	75	04:45	05:03	4
09/12/2004	0.4	875	07:48	08:05	4
10/12/2004	1B	250	11:00	11:13	4
13/12/2004	0.4	625	09:47	09:49	4
15/12/2004	1.6	900	08:36	08:48	5
18/12/2004	0	1200	11:31	11:36	5
19/12/2004	2.25	800	13:27	13:31	5
04/01/2005	0.8	1600	11:36	11:43	2
07/01/2005	A	1450	05:03	05:07	4
10/01/2005	0.8	875	10:31	10:37	5
11/01/2005	0.8	1675	09:32	09:37	5
14/01/2005	B	1600	07:14	07:21	4
15/01/2005	1.6	1575	10:11	10:19	3
19/01/2005	F	1025	13:01	13:10	5
21/01/2005	D	700	12:39	12:43	3
13/02/2005	1.6	75	06:31	06:37	4
14/02/2005	F	300	11:10	11:23	5
17/02/2005	0.8	875	09:37	09:41	4
21/02/2005	1.3	300	10:57	11:01	2
22/02/2005	1B	450	11:23	11:13	4
07/03/2005	0	750	05:31	05:43	5
07/03/2005	0	790	05:50	06:11	4
10/03/2005	0.8	75	05:30	05:36	4
12/03/2005	B	200	06:15	06:21	4
15/03/2005	0	1750	12:00	12:12	5
15/03/2005	0.4	725	07:30	07:37	5
27/03/2005	1B	1040	12:28	12:33	4
29/03/2005	1.3	1350	12:50	13:03	4
01/04/2005	C	1050	07:45	07:54	4
02/04/2005	1.6	500	10:55	11:07	3
02/04/2005	1.6	500	10:55	11:00	3
20/04/2005	0.8	500	09:17	09:20	2
20/04/2005	0.8	500	09:17	09:19	4
21/04/2005	0.8	375	08:47	09:00	2
21/04/2005	1B	650	12:29	12:38	3
21/04/2005	1B	650	12:29	12:33	4

21/04/2005	D	250	09:11	09:17	4
24/04/2005	B	800	10:24	10:37	4
27/04/2005	C	850	09:34	09:43	5
15/05/2005	0.8	600	13:17	11:20	4
26/05/2005	1.6	500	10:13	10:27	3
08/06/2005	0	500	09:31	09:34	5
08/06/2005	0	2225	12:58	13:01	4
22/06/2005	B	125	10:00	10:03	3
23/06/2005	C	25	13:00	13:14	5
24/06/2005	C	850	09:15	09:24	2
30/06/2005	A	300	06:10	06:18	3
05/07/2005	0	B	08:48	08:57	4
05/07/2005	0	B	07:15	07:19	5
11/07/2005	0.4	675	10:48	11:22	3
18/07/2005	1A	E	10:53	10:56	4
18/07/2005	1A	E	13:56	13:59	4
25/07/2005	0	G	07:10	07:40	5
25/07/2005	0.4	D	07:48	07:54	4
27/07/2005	E	1030	10:09	10:11	5
28/07/2005	G	0.4	07:00	07:11	4
29/07/2005	0.4	900	09:29	09:35	5
03/08/2005	E	1600	08:10	08:16	4
14/08/2005	1.6	E	10:30	10:40	4
14/08/2005	A	680	11:00	11:30	4
15/08/2005	0.4	A	07:30	07:35	3
16/08/2005	0	555	05:25	05:31	4
18/08/2005	0.4	300	08:25	08:30	5
19/08/2005	0.4	1375	09:00	09:01	5
19/08/2005	0.4	1375	09:20	10:36	5
19/08/2005	0.4	D	11:25	11:38	4
19/08/2005	D	250	11:37	11:38	5
19/08/2005	D	250	11:50	11:56	4
19/08/2005	D	250	12:09	12:29	5
20/08/2005	0	790	08:15	08:30	4
20/08/2005	E	1050	10:00	10:09	4
21/08/2005	1.6	E	07:40	07:46	2
22/08/2005	2	1950	05:56	06:30	4
22/08/2005	2	1950	06:36	07:30	4
22/08/2005	2	1950	07:30	07:40	4
23/08/2005	C	950	07:52	07:58	4
Average group size (number of gibbons)					4.060241