

Can you tell a gibbon by its call?

Inter- and Intra-group comparison of Kloss's gibbon (*Hylobates klossii*) vocalisations in primary rainforest and peat-swamp forest habitats on Siberut Island, Indonesia.



Emma Fenton

[word count: 12,652]

Thesis submitted for the degree of MSc Conservation,
Dept of Geography,

UCL (University College London)

August 2010



UNIVERSITY COLLEGE LONDON

MSc Conservation

Please complete the following declaration and hand this form in with your MSc Research Project.

I,Emma Fenton.....

hereby declare :

- (a) that this MSc Project is my own original work and that all source material used is acknowledged therein;
- (b) that it has been prepared specially for the MSc in Conservation of University College London;
- (c) that it does not contain any material previously submitted to the Examiners of this or any other University, or any material previously submitted for any other examination.

Signed :

Date :

Abstract

The Mentawai Islands are recognised as being global biodiversity hotspots. They support the greatest density of endemic primates found on any island chain and provide habitat for a vast array of flora and fauna. They are also currently under huge from habitat destruction through illegal logging, the palm oil industry and, more recently, the paper industry. All four of the endemic primates of the Mentawai Islands including the Kloss's gibbon are rated as Endangered or Critically Endangered by the IUCN and although trade of these animals is prohibited by national laws and by the international CITES treaty, hunting for bushmeat still continues at an alarming rate.

The aim of this research was to analyze and compare Kloss's gibbon vocalisations within and between two differently-forested habitats on Siberut Island, W. Sumatra: Indonesia. The vocalisations of the different gibbon types have anecdotally been reported as different and, if this is the case, it could open up speculation about the ability of the gibbons to adapt their behavioural ecology to habitat type and, in turn, enable discussion on the ability of this species to respond to different pressures such as climate change, habitat destruction and hunting.

It is hoped that the ability to discriminate between different groups or individuals based on their vocal characteristics could open the door for more in depth studies on the behavioural ecology of the Kloss's gibbon. Something previously thought impossible because of the identical morphology across all age and sex classes.

Kloss's gibbons were recorded at 5 different locations in the primary lowland tropical rainforest but were not encountered in the peat-swamp ecosystem. Analysis of the vocalisations from the primary rainforest shows that individual gibbons can be identified and distinguished based on the vocal characteristics of their calls; the lack of gibbon observations in the swamp forest led to the proposal of theories that might explain the apparent disappearance of the gibbons from this habitat, and speculation about what this might mean for the species in the future.

Contents

Content	Page Number
List of Acronyms	6
List of Tables	6
List of Figures	7
Acknowledgements	8
Introduction	9
Chapter 1 – Geography	
• 1.1 The Mentawai Islands	10
• 1.2 Siberut	11
• 1.3 The forest habitats on Siberut	11
1.3a The Peleonan Forest	
1.3b Pungut Field Station	
1.3c The Peat Swamp Forest	
Chapter 2 – The primates of Siberut & <i>Hylobates klossii</i>	15
• 2.1. Kloss’s gibbon conservation status	17
• 2.2 Kloss’s gibbon strongholds	19
2.2a Siberut National Park	
2.2b Sipora and the Pagais	
• 2.3 Threats to Siberut habitat and primates	21
• 2.4 Traditional culture	23
• 2.5 Current conservation management for the Kloss’s gibbon	24
Chapter 3 – Literature Review	26
• 3.1 Selection of research focal habitats	26
• 3.2 Kloss’s gibbon vs. other small gibbons	26
• 3.3 Vocalisation studies	30
3.3a Terms, definitions, and expectations for primate vocalisations	
3.3b Vocalisation research	
3.3c Expectations for vocalisations in a tropical rainforest	
3.3d Kloss’s gibbon vocalisations	
Chapter 4 – Research rationale	37
Chapter 5 – Methods	38
• 5.1 Study subjects	38
• 5.2 Field Study sites	38
• 5.3 Vocalisation capture techniques	39
5.3a Fieldwork – Pungut Research station	
5.3b Fieldwork – Swamp forest research site	
• 5.4 Data collection	42
• 5.5 Method adaptations for the swamp	43
• 5.6 Equipment	44
• 5.7 Song bout digitisation	44
• 5.8 Statistical analysis	46

Chapter 6 – Results	47
Chapter 7 – Discussion	55
Chapter 8 – The Future of Kloss’s Gibbon research	61
Chapter 9 – Autocritique	63
References	64
Appendices	
1. The different forests of Siberut and their structural ecology	69
2. GPS data for the research sites and the listening posts	70
3. Full list of equipment and software used for this research	71
4. Transect map of Pungut research station	72

List of Acronyms

Acronym	Description
CITES	Convention on International Trade in Endangered Species
CV	Coefficient of Variation
DPZ	Deutches Primatenzentrum [The German Primate Centre]
GPS	Global Positioning System
IPB	Institut Pertanian Bogor [Bogor University]
IUCN	International Union for Conservation of Nature
SCP	Siberut Conservation Project
SNP	Siberut National Park

List of Tables

Table Number	Description
1.1	Summary of ecological findings from Quinten (2008)
2.1	IUCN assessments of the Kloss's gibbon
3.1	Summary of relevant research on the Kloss's gibbon
3.2	Terms and definitions used when describing gibbon songs
3.3	Principles of sound transmission through a tropical rainforest
3.4	Calling frequencies of different species in the Kloss's habitat
3.5	Deconstruction of the male Kloss's song
3.6	Deconstruction of the female Kloss's song
5.1	Variables noted for each recording
5.2	Vocal variables isolated and analysed from the dataset
6.1	Results from the Discriminant Function Analysis showing the percentage of individuals correctly assigned to their respective groups using all variables
6.2	Results from the Discriminant Function Analysis showing the percentage of individuals correctly assigned to their respective groups using all variables excluding the post-trill elements.

List of Figures

Figure number	Description
1.1	Map showing the location of the Mentawai Islands
1.2	Map showing the extent of the Peleonan forest of northern Siberut
1.3	Aerial view of Pungut research camp
2.1	The other endemic primates of Siberut
2.2	The Kloss's gibbon
2.3	Map showing the location of SNP & the management zones within it
3.1	Map detailing the proposed radiation of hylobatids in Indonesia
5.1	Map showing the location of the research sites
5.2	Map showing the location of the listening posts at Pungut research camp
5.3	Map showing the extent of the Peat-swamp forest in the Peleonan forest
5.4	Map showing the position of the transect in the Peat-swamp forest
5.5	Stylized sonograms of the male Kloss's call
6.1	Map showing the position of the groups and their predicted homeranges
6.2	Graph showing the coefficients of variation (CV) across all individuals for all variables measured
6.3	Graph comparing the CV between groups for all variables measured
6.4	Graph comparing CV between groups for all variables excluding frequency modulation of 1 st post-trill note
6.5	Canonical Discriminant functions showing the clustering of calls around the group centroid for all variables
6.6	Canonical Discriminant functions showing the clustering of calls around group centroids for all variables excluding post-trill elements
6.7	Canonical Discriminant functions mapping all the groups together excluding post-trill variables
7.1	Map showing encroachment into the Peleonan forest from 1988 to the present
7.2	Map showing encroachment with respect to the Peat-swamp forest

I would like to take this opportunity to thank all of the people who made this research possible.

The people at DPZ, who funded the project, trained me to use the equipment, and kept me organised: Thomas Ziegler, Keith Hodges, Kurt Hammerschmidt, Ellen Wiese, and especially Marcel Quinten for his help once I was out of the field and the generous donation of his GIS data.

Dr Muhammed Agil, Pak Lucky, and Aminah at IPB, who managed the administration of my VISA and official documents and helped me in-country.

The staff of the SCP and the other researchers who were my surrogate family while I was away and were on hand when things were going wrong: Jess, Christin, Dodo, Feri, Yohanna, Rose, Pak Tarsan, Ibu Novi, Ibu Rippe, Pak Lucien and many more.

My guides and assistant who helped me collect the data, find the Bilou and live in the forrest. Without them my project would never have got started: Tue, Binson, Bitcar, and Titan.

Finally for Jess, my friends and my family once I got home, for having patience when I was writing and teaching me how to cross roads again.

Introduction

The aim of this project is to characterize and compare Kloss's gibbon vocalisations within and between two differently-forested habitats on Siberut Island, Indonesia. If differences are found it could allow speculation on the ability of this species to adapt to pressures such as habitat destruction and climate change by evolution of communication within and between groups.

The Kloss's gibbon is currently assessed as Endangered according to IUCN guidelines (Brandon-Jones *et al.*, 2004) and is under threat from habitat loss; through encroachment from logging, construction of roads, population growth and agriculture such as coffee and rubber plantations, as well as subsistence agriculture; and hunting for cultural use, and for trade as bushmeat or pets (Nijman, 2001; Campbell *et al.*, 2008; Cheyne *et al.*, 2008; Fuentes, 1997; Geissmann, 2007; Whittaker *et al.*, 2003).

It is important that more is known about Kloss's gibbons as they play an important role in the function and health of the ecosystems that they are a part of. Primates are known to have important roles in forest structure and regeneration through seed dispersal (Chapman, 2005). They have also been used as potential indicators for climate change (Brandon-Jones, 1996). More specifically, it is crucial that more is understood about the populations of Kloss's gibbons that exist on Siberut as it represents the largest patch of undisturbed forest that forms part of this species' extent of occurrence and it is thought that the majority of Kloss's gibbons remaining in the Mentawai Islands exist on Siberut in and around the national park (Fuentes, 1997; Tenaza & Mitchell, 1985; Whittaker, 2005a; Whittaker, 2005b). There is also no current captive population of Kloss's gibbons, or a breeding programme for this species, and there are no plans for one in the near future (Fuentes, 1997).

1 Geography

1.1. The Mentawai Islands are situated 85-135km off the west coast of central Sumatra between $0^{\circ}55' S$ and $3^{\circ} 20'S$ and $98^{\circ} 15' E$ and $100^{\circ} 40' E$ (Fuentes, 2002)

see **Figure 1.1**.

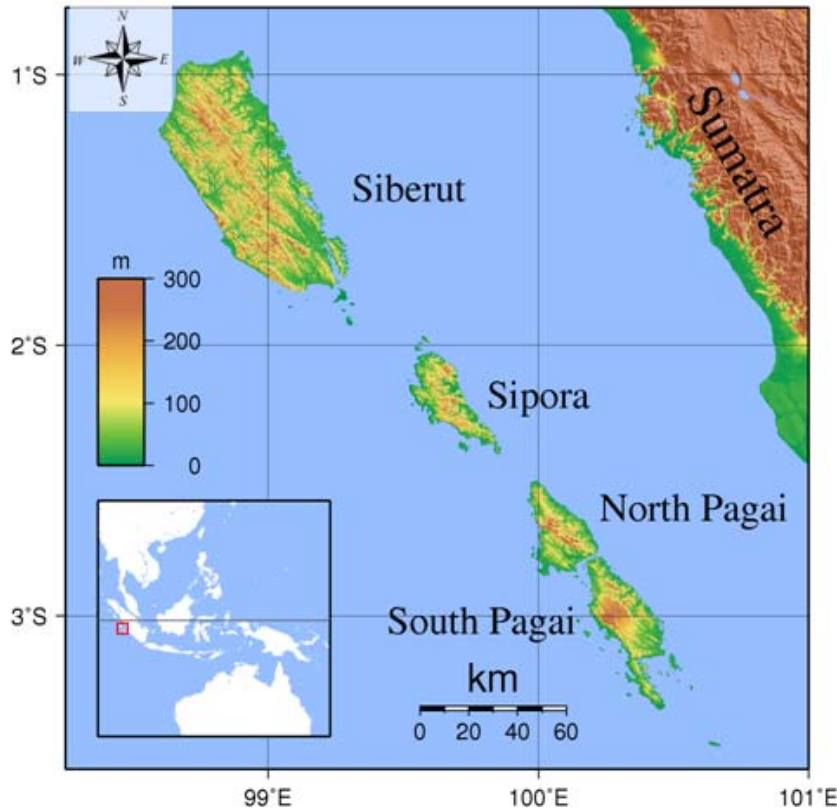


Figure 1.1: Map showing the location of the Mentawai Islands, Indonesia. Adapted from Quinten (2008; p.3).

The Mentawai Islands were formed approximately 200 million years ago due to the subduction of the Indian tectonic plate under the Sunda plate (Waller, 2005; Whittaker 2005a), the ensuing upward shift caused a submergence that created deep sea trenches approximately 1.8km to the west of Sumatra, further west it caused an uplift that created the chain of islands that includes the Mentawais (Waller, 2005). Despite the sea level rising and sinking by over 200m since the Pleistocene, the deep sea trenches have kept the Mentawais separate from mainland Sumatra for over 500,000 years (Whittaker, 2005a; Waller, 2005; Whitten, 1980) despite the fact that the rest of Sundaland (Java, Borneo, Malaya and southern Indochina) was connected by land bridges as recently as 10,000 years ago.

As a result of this separation the Mentawais are considered an important Pleistocene refuge (Brandon-Jones, 1998). They provide unique habitat to a vast array of flora and fauna (Fuentes, 2002), they have the highest level of endemism of any chain of islands, approximately 65% of non-volant mammals in the Mentawais are endemic at genus or species level (Whittaker, 2005a); in an area equivalent to 6550km² (or one-third of the area of Wales) there are four endemic primates (Fuentes, 2002; Tenaza & Mitchell, 1985; Whittaker, 2005b; Whitten, 1980). As a result of this uniqueness, the tropical rainforest on these islands contain many hundreds of potential food species (Whitten, 1984a).

1.2 Siberut is the northernmost and largest of the Mentawai Islands. It is also the best known of the Mentawais, it has the sparsest human population at 4 persons per km², as opposed to 9/km² in Sipora and the Pagais (Tenaza & Mitchell, 1985). It has been estimated that Siberut has been occupied by humans for at least the past 2,000-3,000 years (Fuentes, 2002).

Siberut is visited by about 2,000 tourists per year, mostly to observe the lifestyle and culture of local people (Whittaker, 2005a). Siberut differs from mainland Indonesia and hence other well-studied gibbon habitats, in that it receives very high rainfall (+/- 4,200 mm per annum) and has less fertile soils (Whitten, 1982a).

1.3 The Forest habitats on Siberut and the Mentawai Islands are very similar to those on the Malay Peninsula and Sumatra but they grow with extremely high rainfall and on relatively poor soil (Whitten, 1980). The major forest types on the Mentawai Islands are tropical primary lowland dipterocarp forest, primary mixed forest, secondary forest, *Barringtonia* forest, peat swamp forest and palm-dominated swamp forest; other types present include mangrove, freshwater and sago swamps as well as west coast beach vegetation (Fuentes, 2002; Waller, 2005; Whitten, 1980). **Appendix 1** details the different forest types and their structural ecology.

Although the majority of forest on Siberut is tropical lowland evergreen forest, there are in fact six forest formations that are recognized on the Mentawai Islands: tropical

lowland evergreen forest, brackish water forest, mangrove forest, two freshwater swamps (including the peat swamp that encompasses the second research site for this project), and beach forest (Whitten, 1980).

The tropical lowland evergreen forest can be divided into two main categories: *Dipterocarpus*-dominated, and mixed forest (Whitten, 1980).

The *Dipterocarpus* forest is generally restricted to the hills and higher ridges on Siberut, the emergents in this forest type exceed 70m and the continuous canopy occurs between 30m and 50m. The mixed forest on Siberut typically covers the lower-lying areas and hillsides where the tallest trees are generally less than 50m tall. There is no single dominant plant family but common ones include *Dipterocarpaceae*, *Euphorbiaceae*, *Myristicaceae*, and among the smaller trees *Rubiaceae* (Whitten, 1980).

1.3a The Peleonan Forest of North Siberut, which forms the focus of this dissertation, is recognized for the high density of all four of the endemic Mentawai primate species (Whittaker, 2005a; Whittaker, 2005b). It is one of the last remaining, relatively undisturbed primary rainforests on Siberut (Ziegler *et al.*, 2004). See **Figure 1.2** for location of the Peleonan forest.



Figure 1.2: Map showing the extent of the Peleonan forest on Northern Siberut in yellow (Quinten, 2008; Google Earth, 2010).

The forest also has more accessible terrain both for tourism and research, so although it is only 4,000ha, it is of particular importance with regards to the conservation of these primate species. It was extensively logged around 20 years ago and currently there are low levels of hunting within this region (Whittaker, 2005b).

There is higher food availability in the Peleonan forest compared to the surrounding primary Dipterocarp forest because there are a higher proportion of trees that bear fleshy fruits and therefore it is unusually productive (Whittaker, 2005a,b).

1.3b Pungut Field Station



Figure 1.3: Aerial view of part of Pungut camp, used with permission from C. Richter.

The Pungut field station is located 7 km upstream from the village of Politcioman, along the Sigep River. It was established in 2003 and is based on a 6000ha area within the Peleonan forest (Ziegler *et al.*, 2004). The area is protected at present by contractual agreements between the SCP, local clans and Indonesian officials (Ziegler *et al.*, 2004).

The station itself consists of 7 traditionally constructed wooden buildings and is located in the centre of a radial transect system. The transect system comprises 26 main (spoke) transects of between 1.5-2km length, which are connected by inter-transects that expand outwards from the camp in concentric circles (See transect

map in **Appendix 4**). All of the transects are systematically GPS mapped and are cleared on a regular basis (Ziegler *et al.*, 2004).

1.3c The peat-swamp forest on the northernmost coast of Siberut is the second research site for this project. It lies within the Peleonan forest of northern Siberut and lines the coast. The area lies between 0°56' to 0°58' South and 98°48' to 98°50' East. It is bordered by the ocean in the North and the river Sigep to the East and gives way to the primary lowland rainforest typical of the Peleonan forest around 2.5 – 3.5km from the shoreline. The forest is very flat in comparison to the other research site and does not exceed 10m above sea level at any point (Quinten, 2008). Low-lying flat areas are conducive to becoming peat swamp ecosystems as the topography, coupled with relatively high rainfall, can lead to poor drainage and permanent water logging; consequently, many peat swamp ecosystems are bordered by hills and hillsides that form their natural boundaries.

There has only been one previous researcher at this field site and as such the plant taxonomy is not extensively known. Below is a table summarising the environmental conditions that were documented during the previous study **Table 1.1** summarised from Quinten (2008).

Table 1.1: Summary of ecological findings from Quinten (2008).

Ecological Finding	Description
Dominant tree families	<i>Lauraceae, Myrtaceae, Elaeocarpaceae, Euphorbiaceae, Myristicaceae</i>
Number of tree species (in plot)	43 (local people say there are between 60-70 species in total)
Most abundant tree species	<i>Syzygium almini (Myrtaceae), Knema curtisii (Myristicaceae), Palaquium sp.(Sapotaceae)</i>
Mean tree height	16.3m (76% of trees between 0 – 20m)
Trees display many adaptations to Peat Swamp Ecosystem	stilt roots, buttress roots, pneumatophores, sclerophyllous leaves
Peat layer average depth	>2.3m
Canopy	Open and patchy as a result of the prevalence of young trees (~4.5m).

In comparison to the Lowland tropical forest of the first research site, the Peat Swamp Forest is relatively species-poor, and the canopy is lower and patchy rather than continuous.

2.0 The Primates of Siberut



Figure 2.1: Figure 2.1: The other endemic primates of Siberut from left to right: *Presbytis potenziani* (The Mentawai Leaf-Eating monkey), *Macaca siberu* (The Siberut Macaque), and *Simias concolor* (The pig-tailed langur). From Quinten (2008).

All four of the endemic primates of the Mentawais are assessed as either threatened or endangered by IUCN guidelines (Fuentes, 2002). They all depend on the forest but can avoid competition within habitats by using different forest strata in their ranging and foraging patterns (Whittaker, 2005a; Fuentes, 2002). The populations of the primates on Siberut were estimated by Tenaza & Mitchell (1985) at: 36,000 Kloss's gibbons; 46,000 Mentawai langurs; 19,000 pig-tailed langurs; and 39,000 Mentawai macaques.

***Hylobates klossii* (The Kloss's Gibbon)**



Vernacular Name: Kloss's Gibbon

Local Name: Bilou

IUCN Status: Endangered (En)

Figure 2.2: *Hylobates klossii*.
From Quinten (2008; p.9)

The Kloss's gibbon is the sole gibbon species of the Mentawai Islands (Campbell *et al.*, 2008; Tenaza & Hamilton, 1971); it was discovered in 1902 during a collecting expedition to the islands (Whittaker, 2005a). It is the only Mentawai primate for which a subspecies has not been described that is unique to Siberut despite the fact that all of the Mentawai primates have had a shared bio geographic history (Waller, 2005; Whittaker *et al.*, 2003; Whittaker, 2005a). No phenotypic variation has been noted in the Kloss's gibbon as throughout its range it has a completely black pelage and no facial markings (Waller, 2005), although recent research suggests that there may be variation in the direction of the hair on the forearm (Whittaker, 2005a). This is reflected in the fact that the local name for the Kloss's gibbon remains the same throughout the Mentawai Islands (Whittaker, 2005a).

The Kloss's Gibbon belongs to the family Hylobatidae, within the superfamily Hominoidea (Whittaker, 2005a); it is the sole gibbon species that has a completely black pelage for all of its age/sex classes (Whitten, 1980). Kloss's Gibbons are monogamous, small, territorial, and arboreal apes (Haimoff & Tilson, 1985; Nijman, 2001; Whittaker, 2005a); they are also diurnal and are more omnivorous than any other gibbon species (Tenaza, 1975a; Waller, 2005). Although predominantly frugivorous (up to 72% of the diet is fruit), Kloss's Gibbons will also consume buds, leaves, insects and eggs (Waller, 2005; Whittaker, 2005a; Marshall & Leighton, 2006), this is surprising since they have approximately the same bioecology as other gibbon species and would therefore be expected to have a similar diet, however the diet of the Kloss's gibbon contains relatively few (2%) tree leaves and instead a major constituent (up to 25%) of the diet is arthropods or small animal prey (Nijman, 2001; Whitten, 1982a; Whittaker, 2005a).

The primary form of locomotion for all gibbons, including Kloss's, is brachiation, or 'rapid swinging underneath the branches of trees' (Waller, 2005; Whitten, 1980). This is made possible by the extremely long forearms in relation to hindlimbs that Kloss's gibbons possess, even in relation to other gibbon species (Waller, 2005; Whittaker, 2005a; Whitten, 1984b). Kloss's gibbons preferentially use the lowland primary forest class found on Siberut (Fuentes, 2002).

All gibbons are protected by international law by CITES Appendix I, which precludes all international trade of this species, they are also protected by national laws in the majority of countries that provide habitat for them (Geissmann, 2007).

Competition occasionally arises between Kloss's Gibbons and Mentawai Langurs because they share several behavioural traits, as described by Tenaza & Tilson (1985):

- 1) both are monogamous;
- 2) both prefer to live in hilly, primary forest;
- 3) both are strictly arboreal;
- 4) both sleep in emergent trees 34-55m tall; and
- 5) both advertise their presence with loud, sexually dimorphic vocalisations.
(Tenaza & Tilson, 1985; p. 299)

This competition is overcome because the Langurs exist predominantly on the edges of the gibbon home ranges and therefore never occur within the core/central part of the gibbon territory (Tilson & Tenaza, 1982). Where interactions do occur between these species, the gibbons generally supplant the Langurs (Tenaza & Tilson, 1985; Tilson & Tenaza, 1982; Fuentes, 2002).

The vocalisations of Kloss's gibbons will be discussed in more detail in the Literature Review (p. 26) in association with the relevant related case studies.

2.1 Kloss's gibbon conservation status

86% of all gibbon taxa have been assigned a heightened threatened status over recent years, 39% by two IUCN categories (Geissmann, 2007) and the Kloss's gibbon is no exception.

Recently, current Kloss's gibbon population estimates have been shown to be inaccurate, as the home range sizes used to create them were particularly small, therefore allowing more groups than are likely to exist on Siberut (Whitten, 1982a; Whittaker, 2005a; Whittaker, 2005b). Most recent estimates suggest that there are

approximately 20,000-25,000 Kloss's gibbons in the Mentawai Islands, most of which exist on Siberut and in particular, Siberut National Park (13,190-15,413) (Geissmann, 2007; Whittaker, 2005a). This research has led to the proposal of a more threatened status for the Kloss's gibbon, as the data indicate there might have been a decrease in the population of gibbons of ~50% over the last 25 years (approximately 3 generations) (Whittaker, 2005a). This proposal is based on a 'decline in area of occupancy, extent of occurrence, and/or quality of habitat, and levels of exploitation' (Whittaker, 2005a).

The Kloss's gibbon is currently assessed as Endangered by the IUCN, although this has been the cause of some dispute since the 1980s. **Table 2.1** summarises the assessments made during the course of research on the Kloss's.

Table 2.1: IUCN assessment of the Kloss's gibbon throughout the research history (IUCN, 2008).

Year	Assessment	Researcher (Assessment body)
1986	Vulnerable	IUCN Conservation Monitoring Centre
1988	Endangered	
1990	Endangered	IUCN
1994	Endangered	IUCN
1996	Vulnerable	
2000	Vulnerable	
2005	Endangered	Whittaker, D.
2008	Endangered, A2cd	Whittaker, D.; IUCN

The Justification for the current assessment is based on the work of Whittaker (2005b):

'Endangered due to a past and continued population decline, estimated at more than 50% over the past 45 years (approximately 3 generations) due to hunting and loss of habitat' (IUCN, 2008).

As a result of the IUCN classification and campaigning by different research groups all gibbons were listed under CITES Appendix 1, which precludes all international commercial trade in the listed species. Gibbon species are also protected in their native countries by national legislation (Geissmann, 2007).

Despite these laws the Kloss's gibbon still faces a number of threats; these are discussed in section 2.3 p. 21.

The conservation action currently recommended by IUCN and the researchers who have worked with the Kloss's gibbons is summarized on p. 24.

2.2 Kloss's gibbon strongholds

2.2a Siberut National Park is the only protected area in the Mentawai Islands and thus the only protected area within the range of the Kloss's gibbon (Geissmann, 2007). At 1,926 km² it covers nearly half the island see **Figure 1.2** (Whittaker, 2005b). It is divided into three different areas, which are managed distinctly: sanctuary, traditional use, and park village zones (Whittaker, 2005a). Limited traditional hunting is permitted in the traditional use zones; however it is strictly prohibited in the sanctuary zones (Whittaker, 2005a). Commercial logging is not allowed in either the sanctuary or the traditional use zones. There are three park village zones and no restrictions are placed on the land use in these zones.

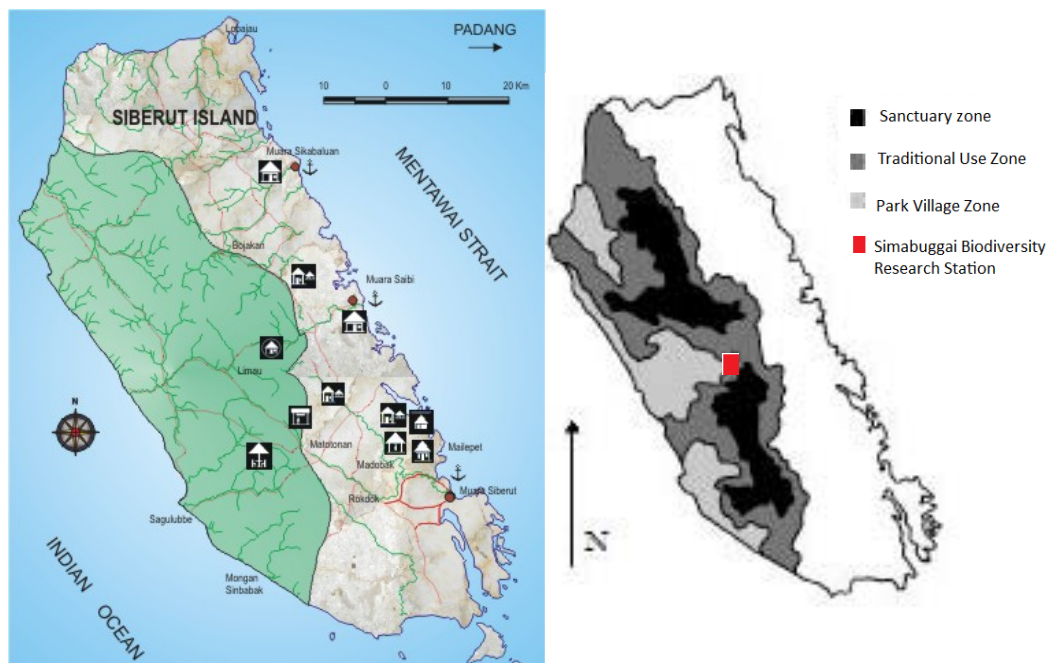


Figure 2.3: Map showing the location of the Siberut National Park (LEFT), the only formally protected area on the Mentawai Islands (adapted from MFRI, 2008), and (RIGHT) the distribution of the different management zones within the park, from Whittaker (2005a).

The park has very rugged terrain and few of the 2,000 annual tourists visit the national park. Unfortunately, despite being a protected area, SNP experiences very little law enforcement, which results in extraction of forest products, both primates for the bushmeat and pet trade, and timber and other forest products for construction and trade (Whittaker, 2005b).

The National Park is the only formally protected area throughout the entire Kloss's range.

2.2b Sipora and the Pagais.

Tenaza (1991) found that local people on the two Pagai islands were converting the forest to plantations for cash crops at a rate that meant the primates were likely to be exterminated by habitat destruction. More recently reports from Sipora suggest that the forest there has been extensively logged and is becoming unsuitable as primate habitat (Brown, *pers. comm.*). Economic development and encroachment into the forest is a big problem on Sipora, particularly for oil palm plantations (IGCMW, 2008). It is estimated that only 10-15% of the island's forest cover remains (Fuentes, 1997).

In 1991 Richard Tenaza proposed the creation of reserves on four of the smaller islands around the Pagais: Sinakak (6km²), Simalegu (2km²), Simatapi (2.5km²), Tinopu (14km²), including the marine environments around these islands (Tenaza, 1991). Sinakak has populations of all 4 endemic primates, while Simalegu and Simatapi have populations of the pig-tailed langurs. Despite not having primate populations, Tinopu was included in the reserve in the hope that it might provide suitable habitat for re-introduction and controlled breeding programmes as these have been suggested as critical prospects to consider thereby ensuring the longevity of the Mentawai primates (Tenaza, 1991).

As yet, these proposed reserves have not received formal protection and it is likely that the habitat will become unsuitable or disappear before they do as there is only an estimated 15% forest cover remaining on both of the Pagai islands (Fuentes, 1997). Fuentes (2002) predicts that the numbers of Mentawai primates on Sipora

and the Pagais, including the Kloss's gibbon, could be halved before the end of the next decade. For this reason Siberut has been described as the last best hope for long-term conservation of the Mentawai primates (Whittaker, 2005a; Whittaker *et al.*, 2003; Fuentes, 1997).

2.3 Threats to Siberut habitats and primates

The main threat to the habitats on Siberut, and by extension the species that occur within them, is fragmentation through logging; agriculture – both subsistence encroachment cultivation and commercial encroachment such as rubber, tea, oil palm, and pine plantations; forest product extraction by local people; increase in human populations and therefore space required for them to live in; and charcoal burning (Cheyne *et al.*, 2008; Fuentes, 2002; Fuentes, 2008; Whittaker, 2005a). There are 2 large companies that control logging concessions that cover 100,000ha and 400,000ha areas of Siberut (mostly in the North). These concession areas are valid for the next 20 years and are actively being logged (IGCMW, 2008). Only 25% of the southern part of Siberut still exists as forest habitat, with the rest having been extensively logged. However, it is not just commercial encroachment that is threatening these fragile habitats, land tenure for use by local people is a traditional right and does not require a permit from Jakarta for encroachment into the forest habitat (IGCMW, 2008). This habitat destruction has a two-fold effect: firstly, it reduces the size of the habitat available to gibbons thereby reducing the number of groups that can co-exist within this space; secondly, it forces gibbons into poor-quality or degraded habitats and therefore they become easier prey for hunters (Fuentes, 1997). Mackinnon (1984) notes that 'even selectively-logged forests are extremely suboptimal habitat for gibbons as they require continuous canopy for their brachiation type of locomotion', thus gibbons can be said to be more affected by deforestation and habitat fragmentation than the other Mentawai primates.

With the increase in human populations, particularly since 2003 when the Indonesian government declared the 'State of Mentawai' as somewhere for

population relocation to occur, the area of forest converted for subsistence farming and cash crops is on the increase (Fuentes, 1997). This habitat fragmentation opens up the forest and allows access to previously inaccessible areas, thereby increasing the likelihood of primates becoming prey to hunting, disease, and capture for the pet trade (Fuentes, 2002).

Tenaza & Tilson (1985) state that the only true predators of the Kloss's gibbon on Siberut are humans and pythons as there are no wild felids on Siberut and the raptors that hunt within Kloss gibbon territories have not been reported to prey on them, however, more recently, Kloss's gibbons have been reportedly preyed on by eagles (IGCMW, 2008).

Kloss's gibbons are hunted for a number of reasons:

- 1) For subsistence use. Although traditionally taboo, hunting of Kloss's gibbons has been on the increase since the arrival of missionaries on the island and the increased availability of air rifles to hunt with instead of bows and arrows (Tenaza & Mitchell, 1985; Tenaza & Tilson, 1985; Whittaker, 2005a; Whitten, 1982b). The Kloss's gibbon is the only Indonesian gibbon species that is now extensively hunted for food (IGCMW, 2008). Traditional hunting methods and uses for the Kloss's Gibbon will be explained further in Section **2.4 (p. 23)**.
- 2) The illegal wildlife trade (Cheyne *et al.*, 2008)
- 3) The use of body parts in the manufacture of traditional medicines (Cheyne *et al.*, 2008)
- 4) Poaching for sale to bar owners as tourist attractions or as pets (Cheyne *et al.*, 2008; Campbell *et al.*, 2008; Whittaker, 2005a)
- 5) Kloss's gibbons are 'a common and appreciated gift among local people' (Campbell *et al.*, 2008)
- 6) For sale as bushmeat in markets both on Siberut and mainland Sumatra (Campbell *et al.*, 2008; Cheyne *et al.*, 2008)

Another major problem for the long-term conservation of Kloss's gibbons is that large populations, an estimated 3,960 – 4,680 individuals, of this species occur outside protected areas (Geissmann, 2007; Whittaker, 2005a) and law-enforcement

within protected areas is minimal at best (Whittaker, 2005b). There is also no captive breeding programme currently in existence or even proposed for the Kloss's gibbon, this makes protection of the populations in the wild all the more important (Fuentes, 2002).

2.4 Traditional Culture

Traditionally, the social organisation of the Mentawai culture, consisted of small village groups of between 30-80 people (collectively called the 'uma') who inhabited and defended small, isolated territories that were centred around a wooden longhouse (also called an 'uma') (Fuentes, 2002). Although farming provided some aspects of their diet, protein was primarily obtained through hunting primates and secondarily from fishing in rivers and the sea (Fuentes, 2002).

All four species of Siberut primates are/were hunted by local people, traditionally with bows and poisoned arrows (Tenaza & Mitchell, 1985; Whittaker, 2005a). With the advent of mechanisation, access to the forest has been drastically improved by the construction of logging roads deep into the forest allowing access to parts previously undisturbed. The traditional hunting techniques have also been abandoned in favour of the more accurate .177 calibre air rifles (Whittaker, 2005a; Fuentes, 2002; Tenaza & Mitchell, 1985).

Catholic and Protestant missionaries have also played their part in the increase in hunting on Siberut, particularly in the last 50 years. The traditional animist religion of the Mentawais precluded the hunting of Kloss's Gibbons, Whittaker (2005a) goes some way to explaining this (square brackets are the author's notes):

'According to Siberut creation myth, long ago there were no humans in the Mentawais, but there were many *Bilou* [Kloss's Gibbons]. The treetops became overcrowded with *Bilou*, and they had a meeting to decide what to do about it. After much discussion it was decided that half the *Bilou* should move down to the ground. They did, and eventually changed into humans' (Whittaker, 2005a: p. 10).

It is for this reason that hunting of the Kloss's gibbon has traditionally been taboo although there are exceptions for special circumstances (Whitten, 1982c). With the advent of the Catholic and Protestant advancement through Indonesia, and the decision of President Sukarno that all Indonesian citizens must adhere to one of five 'accepted' religions: Hinduism, Buddhism, Islam, Christianity (Protestantism) or Catholicism (Ricklefs, 1993); the traditional religion of the Mentawais has been all but lost, along with the related hunting taboos (Whittaker, 2005a).

2.5 Current conservation management for the Kloss's gibbon

As there is only one formally protected area within the Kloss's gibbon range of extent, the management for the conservation of this species is resultantly focused on an area that provides habitat for only half of the estimated gibbon population. In spite of this, the Kloss's gibbon is CITES listed and therefore protected by Indonesian national law (IUCN, 2008). However, the enforcement in the National Park is virtually non-existent and therefore other management strategies were proposed by Whittaker (2005) and subsequently by the IUCN (2008):

- 1) Increased protection for the Siberut National Park, which currently lacks enforcement.
- 2) Formal protection of the Peleonan forest of northern Siberut, which is home to unusually high densities of all four endemic primates but is unfortunately much more accessible.
- 3) Protection of areas within the Pagai Islands by co-operating with a logging company that has been practising sustainable logging there since 1971.
- 4) Conservation education, especially regarding hunting.
- 5) Development of alternative economic models for local people in order to prevent further encroachment for subsistence use and, more critically, to prevent them from selling off their land to logging companies.

Despite these suggestions being made very seriously for the past 5 years, both nationally and internationally, there have been no real signs of improvement in the rate of habitat loss in the Mentawais and the Indonesian government has made no move to create National Parks over any other parts of the archipelago.

3.0 Literature Review

For the purposes of this project, the literature review will be split into three sections: section **3.1** addresses the reasons for selection of the two habitats intended for research in this project; **3.2** will discuss previous research pertaining to gibbon studies, with particular focus on the Kloss's gibbon; section **3.2** will define the terms used in vocalisation research, list the expectations for Kloss's gibbon vocalisations given the restraints of calling in a tropical rainforest, and summarise the research that has been done on primate vocalisation studies, again focusing on the Kloss's gibbon.

3.1 Selection of research focal habitats

The Pungut research area, in the primary lowland tropical rainforest, was selected because Kloss's gibbons have been studied extensively in this area before therefore it could be confidently assumed that there would still be gibbons in this area during the course of this research. Secondly, no vocalisation studies on the Kloss's gibbon have ever been achieved within the Peleonan forest of northern Siberut and therefore it is interesting to discover whether or not groups within a relatively small area can be distinguished on the basis of their vocal characteristics.

The peat-swamp habitat was chosen because previous research has indicated that there are gibbons that use this habitat and, based on their location and their extrapolated homerange, it is possible that there are gibbons that inhabit exclusively swamp habitats. These gibbons were anecdotally described as having different calls from those in the primary rain forest (Quinten, 2008).

3.2 Kloss's Gibbon vs. other small gibbons

The most recent phylogeny of the gibbons in the *Hylobates* genus was published by Whittaker *et al.* in 2007. They disprove the long-standing belief that the Kloss's gibbon is a primitive taxon, instead finding it to be the most recently-derived taxon, sharing characteristics with *H. moloch* – the Javan Silvery gibbon (Whittaker *et al.*, 2007).

The gibbons are proposed by Whittaker *et al.* (2007) to have radiated in a north to south direction, with the northernmost taxon being the basal one – *H. pileatus*. This is shown in **Figure 3.1** below.

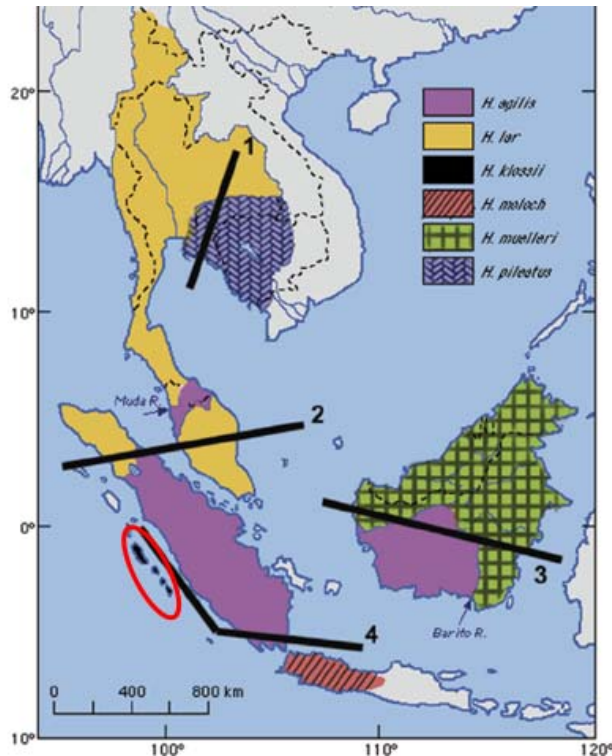


Figure 3.4: Map showing the proposed radiation of gibbon species of the *Hylobates* genus in Indonesia. The Kloss's gibbon extent of occurrence is circled in red. Adapted from Whittaker *et al.* (2007: p.626).

The most detailed comparisons of gibbon morphology and bio-ecology pertinent to Kloss's gibbons were published by Whitten (1984) but only consider the comparisons between *H. klossii*, *H. agilis* (the agile gibbon), and *H. lar* (the lar gibbon).

Morphologically the three species are extremely similar except that agile and lar gibbons have a hair density that is three times higher than on Kloss's gibbons, and the Kloss's gibbon would not be expected to have vastly different ecology from the other two species based on size alone (Whitten, 1984b).

Whitten (1984b) made seven observations about the behaviour of Kloss's gibbons compared to agile and lar gibbons:

- 1) 'It is active for longer each day;
- 2) spends less of the activity period travelling and feeding;
- 3) spends more of the activity period resting;
- 4) lives in a similar-sized home range and territory;

- 5) has a longer day range and travels further and faster at the end of the day;
- 6) spends the same time each day eating fruit, much less time eating leaves and more time eating arthropods;
- 7) uses similar types of night trees'
(Whitten, 1984b: p.225)

Some of these differences can be explained in terms of the choice of locomotion that Kloss's gibbons employ. Brachiation is the primary method of locomotion for all gibbon species, the Kloss's gibbon has the longest forearms of any gibbon species, therefore, for any given amount of time spent travelling, it is likely that the Kloss's gibbon can travel further than the other gibbon species and for less time as this travel is more efficient (Whitten, 1984b). This explains points 2 and 3.

Point 6 can be explained as *H. klossii* has a lesser ability to process and digest hard foods such as plant fibre, since they have fewer molar shearing surfaces than the other gibbon species (Whitten, 1984b). High numbers of shearing surfaces are frequently associated with folivory. It is possible that this statistic is skewed by the fact that the forests on the Mentawais, and in particular the Peleonan forest of northern Siberut, have above-average productivity and a higher percentage of fruiting trees than many forests in the rest of Indonesia (Whittaker, 2005a,b). There is speculation that the reduced folivory of the Kloss's gibbon is due to high concentrations of toxic secondary compounds in the leaves of the Mentawai forests, however there is little evidence to support this assumption.

Points 1 and 5 can be explained by the diet of Kloss's gibbons compared to the other 2 species. Agile and lar gibbons preferentially eat figs at the start and end of each day as this food source contains many seeds, which will release energy slowly over a given period of time, Kloss's gibbons however, prefer to eat figs during the afternoon and fleshy fruits in the evening, therefore they can travel further in the day and feed for longer in order to maximise the energy available to them throughout the night (Whitten, 1984b). This is due, in part, to the scarcity of fig species in Kloss's gibbon habitats. Therefore, the Kloss's may spend more time resting during the relative safety of the day in order to maximise its activity period so that it can ingest more fruit before finding a sleeping tree for the night.

Table 3.1 below summarises the relevant research that has been compiled so far on the Kloss's gibbon.

Table 3.3: Brief summary of all relevant research on the Kloss's gibbon.

<u>Author</u>	<u>Year(s)</u>	<u>Research Summary</u>
Miller, G.S.	1903	[Seventy new Malayan mammals] The original description of the Kloss's gibbon.
Chasen, F.N., Kloss, C.B.	1927	[Spolia Mentawiensa – mammals] First collections and descriptions of mammals from Sipora and Siberut
Tilson, R., Tenaza, R.R.	1974 – 1975, 1980 – 1981	[Monogamy, Territory and song amongst Kloss's gibbons] – First estimate of Kloss's gibbon home range sizes and the number of territories that could potentially exist in the Mentawais. Night tree preference.
Chivers, D.J.	1977	[The Lesser Apes] – The first attempt to assess the number of Kloss's gibbons in the Mentawai Islands.
Whitten, A.J.	1980 – 1984	[The Kloss Gibbon in Siberut Rain Forest] – PhD thesis on the behavioural ecology of the Kloss's gibbon, first study to habituate gibbon groups.
Paciulli, L.M.	2004	[The effects of logging, hunting, and vegetation on the densities of primates in the Mentawai Islands] – Kloss's gibbon population estimates, later proven to be too conservative because of inappropriate survey methods used.
Waller, M.S.	2005	[Vocal diversity of the Kloss's gibbon] – Comparisons of <i>H. klossii</i> between the Mentawai islands and on locations on the south of Siberut.
Whittaker, D.J.	2005	[Evolutionary Genetics of Kloss's Gibbons] – Phylogenetic analysis of Kloss's gibbon diversity using faecal samples collected across the islands.
Marshall, A.J., Leighton, M.	2006	[Food availability and gibbon density] – Estimating gibbon abundance with availability of different food species.
Cheyne <i>et al.</i> ,	2008	[Density and population estimates for gibbons in Indonesia] – Most recent accurate assessment of Kloss's gibbon population numbers throughout the Mentawai Islands.
Quinten, M.	2008	[Survey of the Primate Community of Peat Swamp Forest on Siberut, Mentawai Islands: Indonesia – MSc thesis] – Estimating primate density in the area used for the second research site.

3.3 Vocalisation studies

a) Terms, definitions, and expectations for primate vocalisations.

Waller (2005) states that the accepted definition of a song is ‘a series of notes, generally of more than one type, uttered in succession and so relates as to form a recognisable sequence or patten in time’. This definition was first used to describe birdsong but has now been expanded to other taxa. This is considered appropriate for two reasons: the loud calls of gibbons have all of the features of birdsong; and they are generally complex and long, and can take place without any external stimulus (Whitten, 1980).

Table 3.2 below outlines terms that are used to describe various aspects of gibbon songs and their definitions. These definitions are in accordance with those used by Whitten (1980: p.245, 258; 1982d: p.44, 48)

Table 3.2: Terms and definitions used when describing gibbon songs.

<u>Term</u>	<u>Definition</u>
Note / element	A continuous sound of even or variable pitch with a characteristic structure
Phrase / call	A single note or collection of notes which form a distinct unit within a song
Series	Similar phrases repeated one after the other, forming a distinct section within a song
Song bout	The period between the first and last notes of a collection of two or more phrases, within which no two phrases are separated by more than two minutes
Opening sequence	From the first note of the female song to the beginning of the first great call
Great call	From the first steeply-rising note of the ascent, to the last of the following low-pitched descending notes, whether or not a trill is included
Great call series	From the start of the first great call to the end of the final great call
Female song	from the first note of the opening sequence to the last note of the final great call

The extent to which gibbon calls may be transmitted through a forest is governed by certain principles, identified by previous studies, which are unchanged and unchangeable. These have been identified by Whitten (1982a) and are detailed below.

b) Vocalisation research.

Singing is relatively rare among primates and is restricted to only four genera: the indri (*Indri*), titi monkey (*Callicebus*), gibbon (*Hylobates*) and tarsier (*Tarsius*), although the vocalisations of some great apes (Orang-utans, Gorillas, and chimpanzees) show similarities to gibbon vocalisations in: acceleration of note rhythm, locomotor displays, and volume (Waller, 2005).

Previous vocalisation studies have shown that individual songs are recognised to vary in relation to changing external stimuli such as food abundance, or social contexts (Waller, 2005).

The function of gibbon songs has only recently begun to be understood but traditionally they are said to be maintenance of spatial organisation within a family group and amongst neighbouring ones, and to serve as territorial advertisement to individuals outside of the family group in order to discourage them from intruding into occupied territories (Haimoff & Tilson, 1985). More recently it has been proposed that gibbon songs also transmit other relevant information about the calling individual (Haimoff & Tilson, 1985).

Gibbon songs are species and sex-specific and have been shown to be perfect tools for analysing phylogenetic relationships between taxa, this is possible because certain aspects of songs are considered to be inherited, rather than learnt through group interaction (Waller, 2005). Male gibbons are recognized as making use of vocalisations for mate attraction, territorial advertisement, and defence of their home range (typically between 20-40 hectares) (Waller, 2005).

c) Expectations for vocalisations in a tropical rain forest.

Transmission of sounds through a tropical rainforest is a complex issue. In order to achieve successful transmission of vocalisations, gibbons need to take into account several different factors such as foliage, temperature gradients, ground effects and air turbulence (Whitten, 1982). This is made all the more difficult by the multitude of birds, mammals and insects that compete for different sound frequencies in order to communicate with other individuals of the same species. **Table 3.3** lists the

principles that apply to sound transmission through a heterogeneous, complex medium such as a tropical rainforest.

Table 3.4: Principles of sound transmission through a tropical rainforest. Adapted from Whitten (1980; 1982).

<u>Principle</u>	<u>Source</u>
Sounds with wavelengths shorter than objects in the sound path will be reflected, whereas longer wavelengths will not.	Stephens & Bate (1966)
Lower frequency sounds are absorbed less rapidly by humid air than high frequency sounds.	Evans & Bass (1972) IN Waser & Waser (1977)
Vocalisations from sites above the range of ground effects and at times of minimum acoustical interference increase transmission distance.	Waser & Waser (1977)
Complex structural properties of forests produce 'sound windows', and at these frequencies sound attenuation is less than for lower or higher frequencies.	Morton (1975) Haimoff & Tilson (1985)
Temperature gradients, such as those through the forest strata in which temperature increases with height, will refract sound downwards, causing it to be trapped and attenuated within the forest.	Waser & Waser (1977)

It is reasonable to expect that, given the limitations that gibbons face when producing vocalisations and the limitations of their own laryngeal morphology, they have evolved suitable adaptations that minimise the attenuation of their calls in order to guarantee maximum transmission distance (Whitten, 1980).

Therefore, according to these principles, gibbons should produce vocalisations with the following properties:

- Relatively low-frequency notes
- from song-sites high above the ground
- at times when the difference in temperature between the ground and the canopy is least and when fewest other animals are calling in the same frequency range (i.e. in the few hours before dawn)

Schneider *et al.* (2008) state that, because of the scattering and reverberation effects of the different forest media and background noise, Kloss's gibbon loud calls should be 'low-pitched and whistle-like with low-frequency modulation'. Interestingly,

Kloss's gibbons were the only primate on Siberut that fulfilled the predictions for vocalisations both structurally and in their utilisation (Schneider *et al.*, 2008).

As Kloss's gibbons generally inhabit dense forest habitat, they have evolved a narrow frequency range for their vocalisations that is perfectly adapted for long-range communication within this habitat in order to maximise the transmission over large distances (Haimoff & Tilson, 1985).

Table 3.4 lists other organisms that compete for frequencies in Kloss's gibbon habitat and the frequencies that they call at.

Table 3.5: Calling frequencies of competitor organisms within Kloss's gibbon habitat. Adapted from Whitten (1980).

Organism	Frequency (kHz)
cicadas & orthopterans	3.0 – 5.4
→ except <i>Pompomia decen</i>	→ 2
Majority of birds with loud songs	1.8 – 4.5
→ except hill mynahs & asian fairy bluebirds (but only briefly)	→ 0.6 – 0.8
→ greater coucal (low frequency notes sung repeatedly)	→ 0.3
Siberut monkeys	0.3 – 1.4

d) Kloss's gibbon vocalisations.

Gibbon vocalisations are affected by many factors, including weather, ambient temperature, topography of the area, and human disturbance (Cheyne *et al.*, 2008). Waller (2005) found that temperatures had to reach a minimum of 21.5 °C, in the hour before dawn (Whitten, 1980) with little or no rain during the night before Kloss's gibbons will sing.

Whitten (1980: p.271) divides Kloss's gibbon vocalisations into 4 major classes of song bout:

1. Pre-dawn male songs;
2. Post-dawn male songs (before female songs or if female songs did not occur);
3. Female songs; and
4. Post-dawn male songs (after female songs).

The order of gibbon vocalisations seems to be pre-determined, by other gibbons within the family group, other gibbon groups, and external stimuli such as weather

and ambient temperature. Despite these restrictions, Whitten (1980) found that both male and female gibbons have a tendency to sing most frequently at about 08:30.

Male calls

Male Kloss's gibbons sing, on average, once every 2.5 days before dawn, after dawn once every 9.8 days, and overall once every 1.7 days (Tenaza, 1975b; Waller, 2005; Whitten, 1980). The male vocalisations occur predominantly in the sleeping trees during the few hours that precede dawn (79%) (Haimoff & Tilson, 1985; Tenaza, 1975b; Whitten, 1980; Whitten, 1982d). This is because the sleeping trees tend to be emergents i.e. tall trees that stand above the canopy, that therefore allow maximum transmission of vocalisations (Whitten, 1980). Male vocalisations also occur in the 5 hours after dawn (19%) and can also occur in the mid-morning and at other hours although this is less common (2%) (Tenaza, 1975b). Song bouts can last up to 2 hours, which comprises almost 20% of the gibbon's activity period (Whitten, 1980).

The distance from which a male call can be heard is disputed in literature, ranging from 500-700m, as reported by Tenaza & Tilson (1977) to 1.5km, as reported by Whitten (1980). Male Kloss's gibbons frequently sing at the same time as gibbons in adjoining territories, this 'countersinging' is considered a form of competition between the males (Waller, 2005). Male gibbons countersing while they are separated by distances of 150-500m (Tenaza, 1975a). The differences between their songs allow them to exchange information without coming close to one another (Haimoff & Tilson, 1985).

The male song has been described in detail by Whitten (1980: p.248), the different phrases are listed and described in **Table 3.5** below.

Table 3.6: Deconstruction of the male Kloss's gibbon song. Adapted from Whitten (1908: p.248).

<u>Phrase</u>	<u>Description</u>
First	Single <u>pipes</u> are given, which can be heard from about 250m away. Phrases of double, triple or quadruple pipes develop, and intervals between them vary from about 4 minutes at the outset, to 10 seconds as the song progresses.
Second	The pipes are followed by descending <u>whoos</u> , reminiscent of the first notes of the tawny owl, which eventually supersede the pipes. In the later stages, the single whoo is followed by one or two slightly shorter whoos with a narrow frequency range.
Third	The whoos give way to <u>whoops</u> . Whoops are often preceded by whoos initially, but later the whoos are superseded by high pipes that start the phrase. These whoops increase in number up to about seven consecutive notes, and each phrase generally finishes with one or two shallow descending whoos.
Fourth	The trill develops, preceded by a number of whoops, and usually followed by one or two shallow whoos.

Female calls

Female Kloss's gibbons sing, on average, once every 4-5 days (Tenaza, 1975b), all female vocalisations occur in the 4 hours after sunrise, once the gibbons have left the sleeping tree for the day (Tenaza, 1975b; Haimoff & Tilson, 1985; Waller, 2005). The female vocalisations are predominantly given after dawn, generally after the first male call of the day (Whitten, 1980).

The female call or 'Great call' of the Kloss's gibbon was first structurally deconstructed tentatively by Whitten (1980), it was this research that established that each great call had specific 'quantifiable physical features' that could be statistically tested in order to prove or disprove individuality in the calls (Haimoff & Tilson, 1985). Through the course of this research and later studies, the great calls came to be used as indicators of the presence of gibbon groups because lone or 'floating' females never call, whereas 'floating' males have been recorded, therefore a female call is likely to be an indication of group presence (Whittaker, 2005a).

Table 3.6 describes the deconstructed female Kloss's vocalisations, as described by Whitten (1980) and Waller (2005).

Table 3.7: Description of the different phrases from the female Kloss's 'great call'. Adapted from Whitten (1980: p.258) and Waller (2005: p.7).

Phrase	Description
First	The initial notes of the opening sequence are like quiet coughs, these are single-pitched hoots (~0.7kHz), but the main notes soon begin.
Second	After about three minutes of the main notes, a longer rising note is given that denotes the initiation of the great call series (0.6 – 1.0kHz) with fast bubbling notes (1.0 – 1.2kHz). Each great call lasts for approximately 30 seconds.
Third	The last phrase of a great call is the interlude, with slower falling notes (1.0 – 0.4kHz). The great calls are separated by an interval of approximately 30 seconds. During these intervals, whoops are given by the females.
Fourth	Great call series can last for up to 20 minutes, individual great calls lacking the trill are given most frequently at the start of a series.

4.0 Research rationale

The aim of this study is to characterize and compare Kloss's gibbon vocalisations within and between two differently-forested habitats on Siberut Island, Indonesia – Primary tropical lowland forest, and peat swamp forest. The study will be used to describe the vocal flexibility of Kloss's gibbon songs and will determine the extent to which the gibbons use the peat swamp forest habitat. As recently as 20 years ago research states that *H. klossii* was rare in the swamp forests on Siberut (Whitten, 1980). With no evidence to indicate that these studies were incorrect when published, it must be assumed that Kloss's gibbons have moved to inhabit the swamp forests relatively recently – in the last 20 years. This is likely due to the devastating effects of logging and other threats that were outlined in section 2.3. The supposed ability for the gibbons to move into and colonise new habitats is, in theory, a promising glimpse of their ability to survive as a species. However, all of the swamp forest on Siberut lies outside the boundaries of what little protected area exists in the Kloss's gibbon home range. Furthermore, the swamp forests are predominantly coastal, and subsequently at risk from being submerged due to the changing sea levels that have been predicted with the onset of accelerated climate change (Meehl *et al.*, 2005). Furthermore, the Peleonan forest itself, which encompasses both field sites, has been recognised as being of particular importance to all of the Mentawai primates, not just the Kloss's gibbon and so a better understanding of the gibbons and other primates within this area could lead to international pressure to preserve this unique habitat.

If the gibbons have indeed colonised a new habitat then it is important to find out how this impacts on their behavioural ecology, if the truisms of past research are still applicable, and how current conservation imperatives need to be adapted in order to account for this new behaviour. If they are no longer to be found in the swamp then it must be investigated because it could imply a reduction in the 'fitness' of the Kloss's gibbon as a species and a decrease in the ability of the gibbons to adapt to habitat pressures.

5.0 Methods

The aim of this research is to characterize and compare Kloss's gibbon vocalisations within and between two differently forested areas in the Peleonan forest of northern Siberut, Indonesia.

Vocalisation studies can be broadly separated into 2 different categories according to the purpose of the research: 1) those used for census techniques, and 2) those used to characterize specific vocalisation characteristics.

Where the research looked simply at the presence of groups i.e. primate census research, generally each vocalisation 'incident' is regarded as indicative of the presence of a 'group' – anything from a lone 'floating' male to a complex group comprising many males and females. In the case of Kloss's gibbon, it is the female great call that is used to indicate the presence of a group as no individual females had been recorded for this species (Whittaker, 2005a).

Where the aim of the research was to specifically characterize the vocalisations, the methodology generally involves the use of 'listening posts' that offer the best opportunity for the researcher to record the calls with the minimum of obstruction and therefore distortion of the call (Waller, 2005; Keith, 2005).

5.1 Study subjects

The subjects of this study were wild populations of Kloss' gibbons. 5 groups (individuals) were recorded and a total of 154 calls were of sufficient quality to be used for statistical analysis.

5.2 Field Study sites

Gibbon songs were recorded from two locations, as shown in **Figure 5.1**. GPS points for the research sites and the listening points are listed in **Appendix 2** along with topographical data. These study sites were chosen as Kloss's gibbons have been observed or studied at both of the sites previously.

Pungut research camp is located in primary lowland tropical rainforest, the area is not formally protected and has been recorded as having unusually high densities of the four endemic Mentawai Primates. The camp was established in 2004 by SCP and has been used for previous research on Kloss's gibbons.

The Ecolodge (PaleLeukLeu) is located on the northern coast of Siberut. The beach gives way to a swamp and then a peat-swamp forest, which is the second research focus site for this project. The structure of the forest here is very different from that

The topography of the forest plays a big part in the ability of the calls to be transmitted and affects the distance over which they can be heard. For this reason it was decided that hilltops would present the best opportunity for obtaining gibbon vocalisations for two reasons: 1) The calls can be heard over greater distances as there are fewer obstructions between the calling individual and the researcher, 2) if on a hilltop there would be a greater possibility of being closer to a calling individual at the start of the call sequence.

The 'sound window' was defined by Haimoff & Tilson (1985) as being the frequency at which the complex structural properties of a rainforest least attenuate the sound that is being isolated. For this reason, the sampling frequency for the recordings was chosen as 44KHz in order to minimise the effects of insect noise on the recordings.

The location of the recording sites is shown below in **Figure 5.2**.

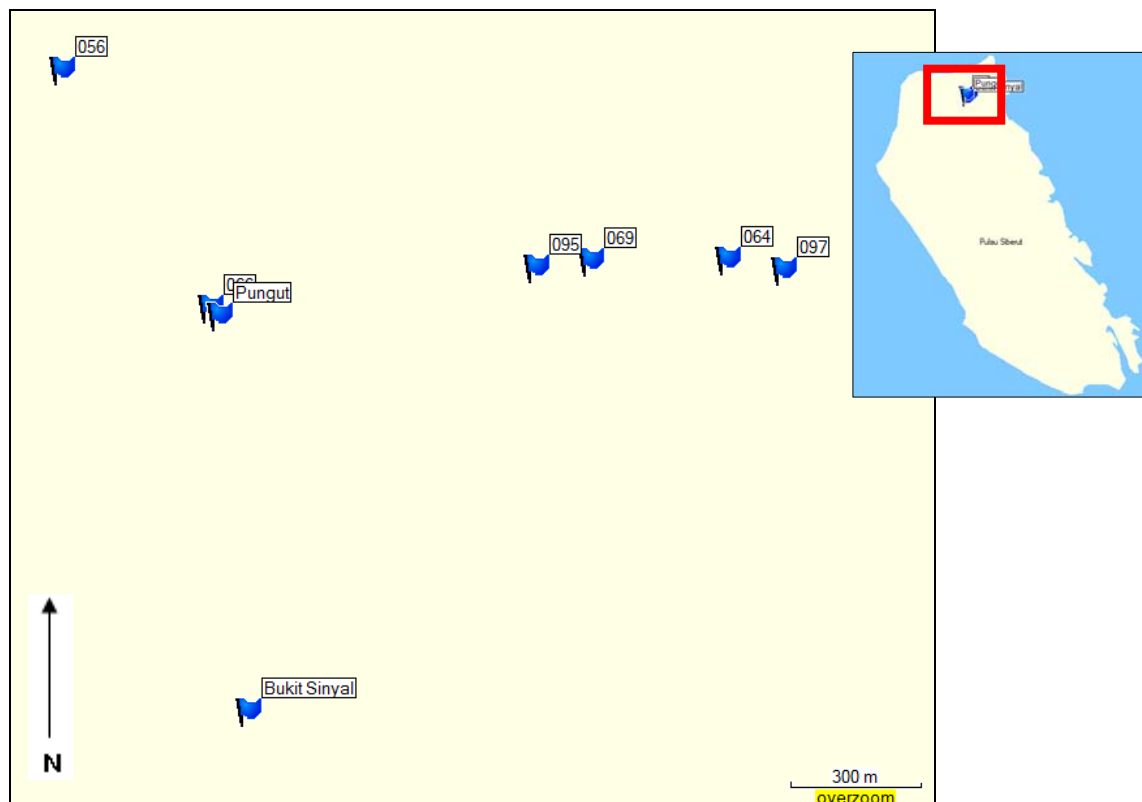


Figure 5.2: Map showing the location of the listening posts in relation to the Pungut research camp.

5.3b Fieldwork – swamp forest research site

Figure 5.3 shows the estimated extent of the swamp forest on Siberut, in relation to the boundaries of the Peleonan forest area. It is bordered on two sides by water: the sea in the North and the River Sigep in the East, then on the western border there is the town of Sikapogna, which is expanding and encroaching on the forest.

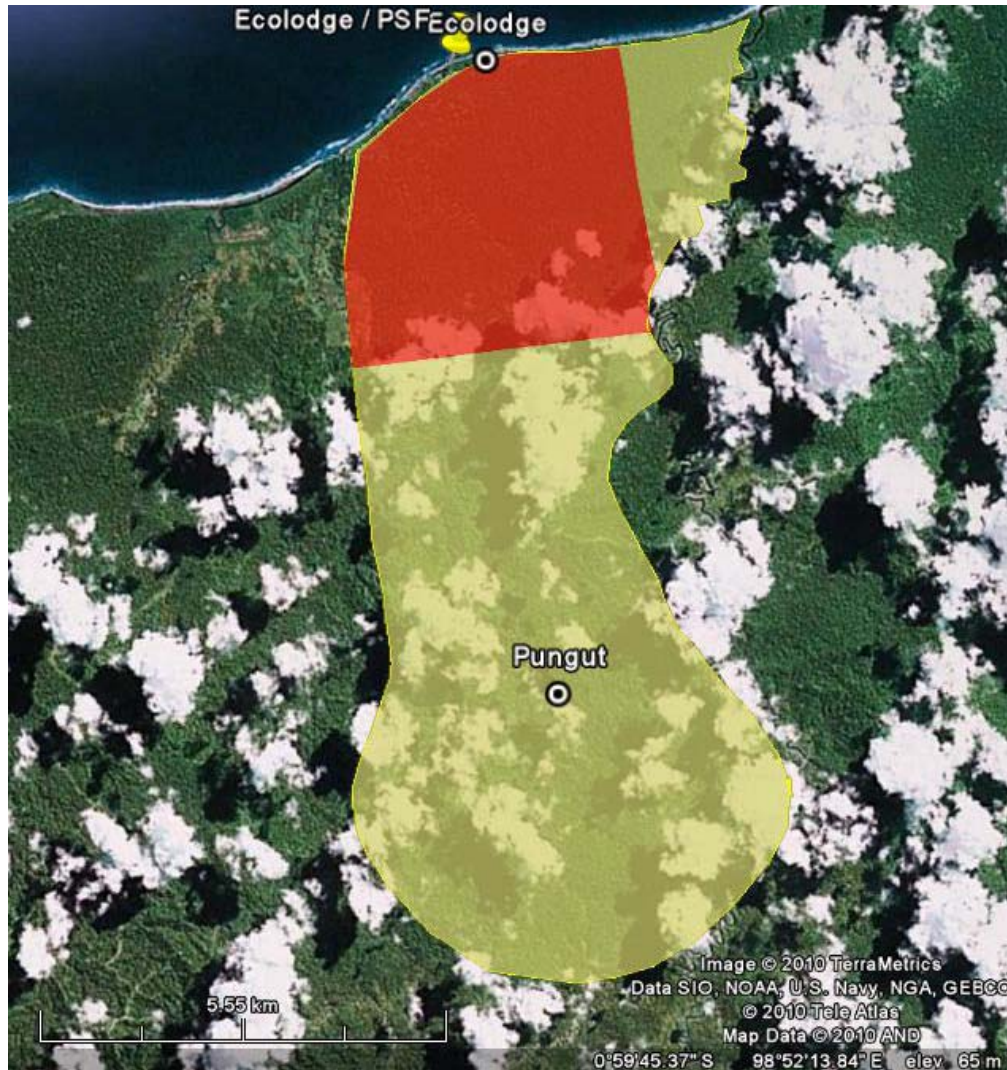


Figure 5.3: The extent of the swamp forest within the Peleonan forest area. The yellow area denotes the boundaries of the Peleonan Forest; the red area denotes the estimated boundaries of the Peat-Swamp Forest ecosystem.

As the peat swamp forest is predominantly flat, with little elevation more than 10m above sea level, a different approach had to be taken in order to try and find the gibbons.

A central transect was cut roughly due South from the PaleLeukLeu on the beach trying, where possible, to follow the main transect cut by Quinten (2008). The rationale behind this decision was twofold: 1) the transect would be marginally easier to cut as there had been one there previously; 2) It would make the results of this study directly comparable with those of Quinten (2008) therefore giving a good indication of the population dynamics of the gibbons inhabiting the swamp areas.

Once the central transect had been established, secondary transects would be cut at intervals from the main transect, similar to Quinten (2008) in order to enable location identification of different groups.

Figure 5.4 shows the original transect system cut by Quinten (2008) and the transect system cut by the researcher for the purpose of this study.

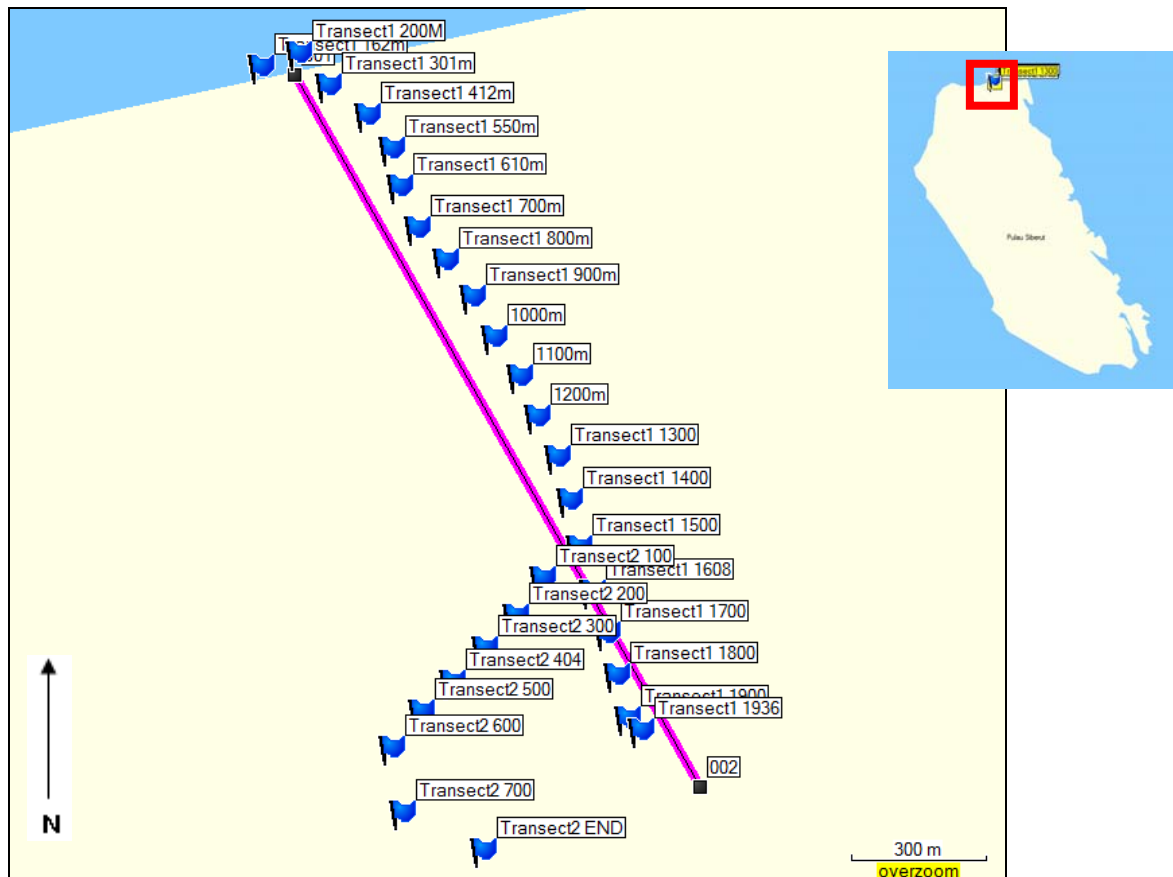


Figure 5.4: Map showing the position of the transect in the peat-swamp forest. The purple line denotes the transect cut by the previous researcher (Quinten, 2008), the blue flags mark waypoints along the transect cut during this research.

5.4 Data Collection

The equipment was provided by the German Primate Centre (DPZ) and a weeklong training period was completed prior to travel to the research site in order to ensure that the techniques being used in the study were perfected. The vocalisations that were recorded were done so using the method detailed in this section of the project and using the same equipment.

The research was conducted with the help of 3 experienced Mentawai villagers, *Tue Salamanang*, *Binson Salamanang*, *Bitcar Salamanang*¹. Their local expertise was crucial for estimating the distances to calling individuals, cutting transects in the swamp forest, and finding appropriate locations to record from. All three had worked for the SCP in some capacity for years, and *Tue* had experience working alongside researchers studying the Kloss's gibbon.

It was accepted that only one male song bout would be recorded each day spent in the field as it would not be possible to obtain good quality recordings for more than one group as that would necessitate moving from one group to another or being at an intermediate point between the two calling groups and compromising on recording quality. The female songs were recorded *ad libitum* as there was no way of predicting where the group would be if and when the females called.

The listening posts were visited from 04:30hr until 06:30hr (sunrise), when the male Kloss's called, unless there was rain. If there was rain the team remained in camp until it stopped for 3 reasons: 1) the Kloss's do not tend to call during rain, 2) the rain could potentially damage the equipment and therefore the risk of damage outweighed the potential benefit of achieving recordings, 3) the quality of recordings during the rain, even if close (<100m) to the calling individual is extremely poor as there is much more interference and disturbance between the calling individual and the researcher.

For each recording a number of variables were noted, as shown in **Table 5.1** below:

Table 5.8: Variables identified and noted for each recording.

Group I.D.	Date	GPS	Time (start of call)	Duration	Distance from calling individual (m)	Compass Bearing	Recording level
------------	------	-----	----------------------	----------	--------------------------------------	-----------------	-----------------

5.5 Method adaptations for the swamp

The survey design for the peat swamp forest had to be altered because the gibbons were not encountered near the central transect in the swamp. They were heard 2-3km further South-West. It was decided that instead of cutting subsidiary transects similar to those of Quinten (2008), a second long transect would be cut from 1500m of the first transect towards the gibbons that were heard calling in order to try and locate the groups. Once the second transect had been cut it became apparent that the gibbons were much further from the periphery of the swamp forest than had previously been experience (Quinten, 2008). For this reason it was not possible to

¹ Instead of being a 'family' name, the second name for the Mentawai people (*Salamanang*) indicates affiliation with one of the clans in the village.

obtain recordings from the swamp as the gibbons were never heard within 4km of the coast, in contrast to the findings of Quinten (2008). The reason for this apparent disappearance of the gibbons from the peat swamp habitat will be addressed in detail in the discussion.

5.6 Equipment

The calls were recorded on a Marantz Solid State Recorder (model PMD661) using a Sennheiser ME66 shotgun unidirectional recorder with a K6 power module. In order to minimise the disturbances caused by wind or rain and to protect the microphone from the humidity at the field site a rubber-foam MZW 66 pro-windscreen wind guard was used.

This equipment has already been used in order to compile data on the vocalisations of Mentawai primates and was therefore deemed appropriate for this study (Schneider *et al.*, 2008).

Navigational data and listening point locations were taken with a Garmin 60CSX GPS. This was chosen because of its durability, robustness and proven record of being able to take GPS waypoints even under dense tropical rainforest canopy. A full list of equipment and software used can be found in **Appendix 3**.

5.7 Song bout digitisation

The data was digitised using Avisoft SASLab Pro bio-acoustic software. In order to make the results of this research comparable to those of other vocalisation studies a standard set of variables will be measured and analyzed. These are listed in **Table 5.2** below.

Table 5.9: Vocal variables analyzed from the dataset.

Variable	Description
Duration of call	Time from start to end of phrase (seconds)
Number of elements in the call	Count of the total notes in the call
Maximum frequency in the call	Measured in Hertz
Number of pre-trill elements in the call	The total number of notes that occur before the trill in the call
Duration of pre-trill notes	The time from the start of the first note to the final note before the trill phrase (seconds)
Maximum frequency of pre-trill notes	Measured in Hertz
Number of notes in the trill	Number of notes that occur in the trill phrase
Duration of the trill	Time from the start to the end of the trill

	phrase (seconds)
Minimum frequency of the trill	Measured in Hertz
Maximum frequency of the trill	Measured in Hertz
Frequency modulation of the 1 st post-trill note	Difference in frequency from the start of the 1 st post-trill note to the end of the 1 st post-trill note. Measured in Hertz
Number of post trill notes	Count of the total number of notes that occur after the trill phrase
Duration of post-trill notes	Time from the start of the 1 st post-trill note to the end of the final note in the call (seconds)
Maximum frequency of post trill notes	Measured in Hertz

Each male great call has three elements: pre-trill, trill, and post-trill as shown in **Figure 5.5**.

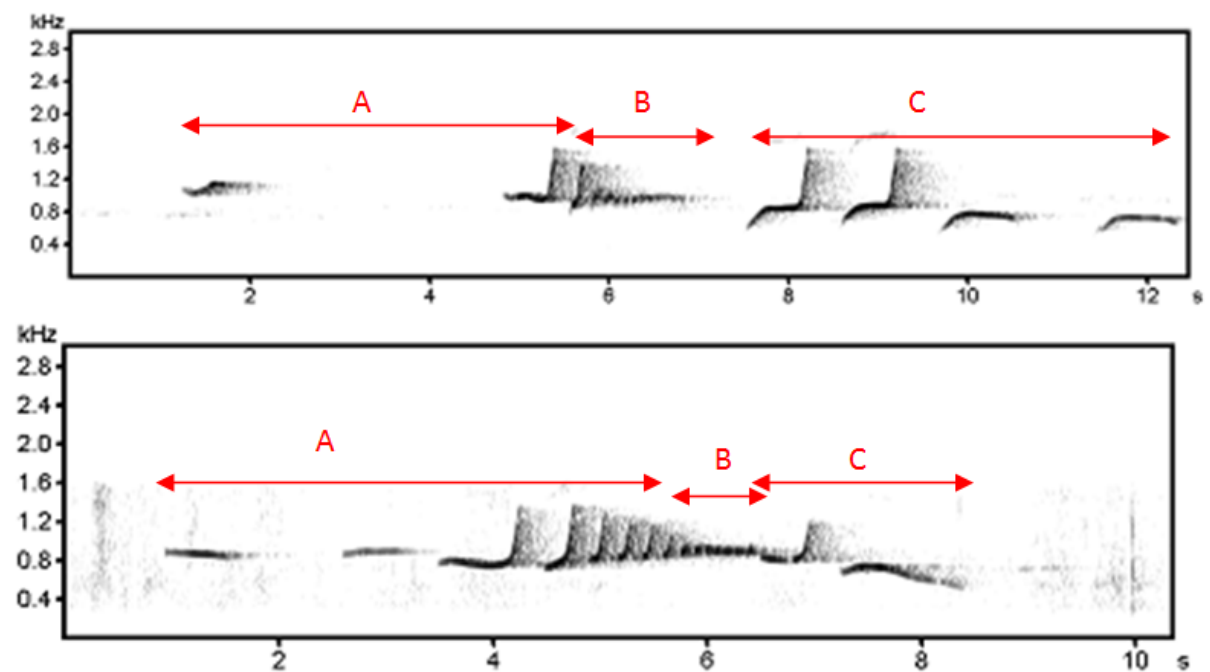


Figure 5.6: Stylized sonograms showing the three elements in each call. A = pre-trill element, B = trill element, C = post-trill element.

The calls were digitised using a 16-bit sampling size and 44.1 kHz sampling rate. Avisoft was chosen because of the ease with which sounds can be edited efficiently without requiring specialised training.

Only calls with all three elements were digitised, fragments were left out. Fragments included aborted calls and also the 'whoos' that are sung in the initial stages of a song bout before the more complex calls start.

5.8 Statistical Analysis

The data generated from Avisoft were then analysed using SPSS 14.0 for Windows by Discriminant Function Analysis (DFA). DFA is used to determine which variables can be used to discriminate between naturally occurring groups.

DFA works with data that has already been classified in order to establish rules for future classification of additional data. By using DFA, it is hoped that the different groups within and between habitat types on Siberut can be isolated and differentiated in a statistically significant manner.

A function that is selected by the DFA is either one of the variables isolated from the data, or a combination of variables that can represent themselves and other variables as a result of linear correlations. The variables that were chosen for the functions were accepted or rejected according to Wilks' λ test. The λ coefficient is defined as 'the proportion of the total variance in the discriminant scores not explained by the differences among the groups' (Landau & Everitt, 2004). It tests the differences between the means of several groups using a combination of several variables.

The prior probabilities – the probability that a sample will be assigned to the correct group by chance – were adjusted according to the group size automatically using SPSS.

Tables showing whether or not a call had been correctly assigned to a group by using the functions were cross-validated using the 'leave-one-out' methodology; this gives a more conservative estimate of correct predicted assignment.

Canonical discriminant functions are used to visually show: a) how tightly the values cluster to the centre point ('centroid') in the functions for a group as a whole, and b) how closely clustered the group centroids are, thereby showing how distinct the different Kloss's gibbon groups are.

6.0 Results

The work at the second research site at the Ecolodge did not yield any results as the gibbons were not encountered in the peat-swamp forest. Hypotheses as to why this apparent disappearance might have occurred are suggested in the Discussion section. As such, a comparison between the populations in the rainforest and those inhabiting the swamp forest is not possible. The results chapter therefore focuses on the data collected from the Pungut research site.

The basic descriptive statistics will be discussed concurrently with the results presented here; the results of the Discriminant Function Analysis will be outlined in this chapter and then examined in the discussion chapter.

Field Time

I was able to complete 34 days of fieldwork and accrue 289 hours of field time, the majority of this time was on subsequent days. Unfortunately there were days where fieldwork was not possible because of the weather, this happened on 7 occasions, and I was unable to work on the weekends because the local villagers who acted as guides had to attend church.

Group distribution within the research site

Figure 6.1 shows the distribution of groups in the study area.

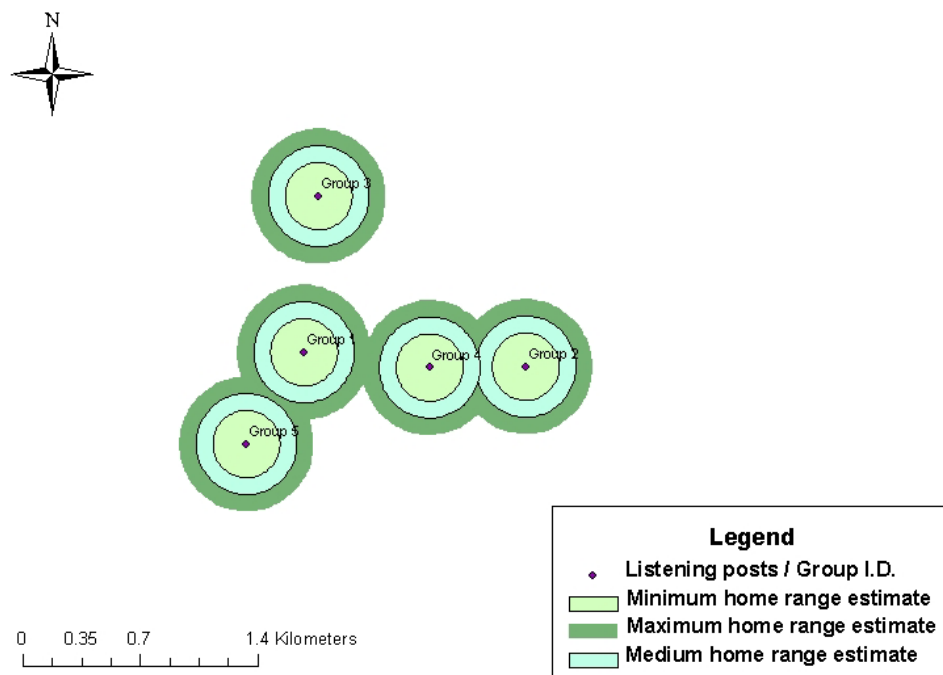


Figure 6.7: Map showing the position of the listening posts/sleeping trees with visual representation of estimated gibbon home range sizes.

The estimated home range for the Kloss's gibbon is 20-40 hectares; this is displayed on **Figure 6.1** as concentric circles. It is important to note here that home ranges are unlikely to be perfect circles but these represent the most widely-used visual representation for primate home ranges.

The home ranges are visually depicted as 'buffer zones' extending out from the position of the sleeping/calling tree. The rationale behind this is that the sleeping trees tend to be chosen in the middle of the Kloss's home range, as has been found in previous research (Whitten, 1980; Tenaza, 1975b).

The light green circle denotes the boundary of a hypothetical home range at the inner limit of the estimate from previous research, the dark green circle represents the same boundary at the outer limit of previous estimates, and the blue circle shows an intermediate state.

Whittaker (2005a) found that Kloss's gibbons tend to inhabit areas more similar to the lower end of the home range size, in addition, the higher productivity of the Peleonan forest has led to suggestions that the gibbons in this habitat might have home ranges as small as 6-7ha (Tenaza, 1975b) as a result of reduced need for extensive foraging between food sources. With these suggestions in mind I can conclude that, given the minimal overlapping between my projected home-ranges, it is likely that the groups I have identified are separate. The only possible exception is Group 4 and Group 2, it could be argued that these are the same group because there is a degree of overlap between the projected home ranges. I am confident this is not the case for 2 reasons:

- 1) Sleeping trees tend to be in the centre of Kloss's home ranges and do not move a large distance within that area (Whitten, 1980; Tenaza, 1975b).
- 2) The boundaries between Kloss's home ranges are generally dictated by topography, the centre of the home ranges is generally found on a hilltop and the boundaries normally follow valley floors (Tenaza, 1975b). The sleeping trees for both Group 4 and Group 2 are on hilltops and are separated by a valley.

For these reasons I can conclude that Group 2 and Group 4 are in fact separate groups. All further statistical observations are based on the assumption that I have 5 distinct groups or individuals.

Intra-individual diversity

Coefficients of variation (CV) were calculated for each of the variables across the entire sample. This shows the degree of variation within a measure with respect to the mean.

These are detailed in **Figure 6.2**. As can be seen from **Figure 6.2**, the coefficient of variance for most of the variable is relatively low; however this is not true for three of the variables: 1) Frequency modulation of the 1st post-trill note, 2) Number of post-trill notes, 3) Duration of post-trill notes.

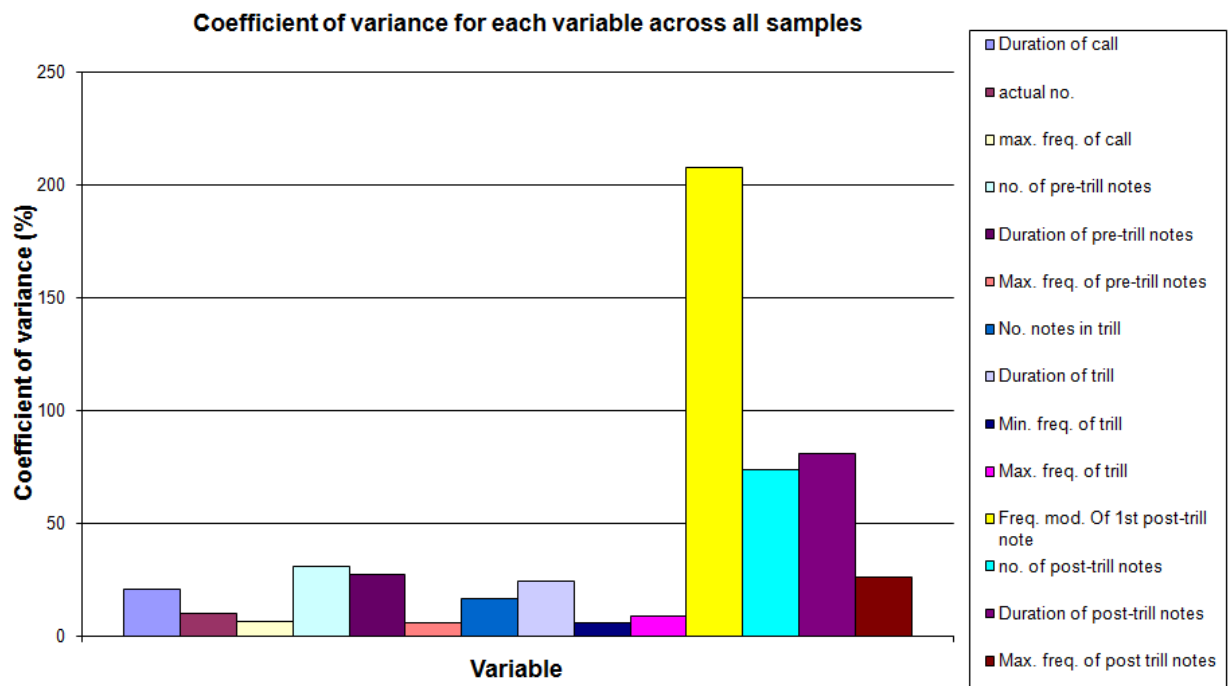


Figure 6.2: Graph showing the coefficient of variation for all the variables studied.

The large variance for the frequency modulation can be explained because, for some of the calls, the post-trill note is a descending whoo-oo and therefore the frequency at the end of the note is lower than that at the start of the note producing a negative frequency modulation, and for other calls, the first post-trill note is similar to the ascending notes of the pre-trill phrases producing a large positive frequency modulation and hence the variance across the sample is very large.

The large values for the number of post-trill notes and duration of post-trill notes is simply due to a large range of values for this variable, hence a large coefficient of variation.

Intra-group diversity

Figure 6.3 compares the coefficients of variation between the groups across the whole set of variables. The greatest values fall within the 'Frequency modulation of 1st post-trill note' category. As this large value has been explained by the reasoning above, the results for this variable are omitted so that the values for the other variables can be examined. This is shown in **Figure 6.4**.

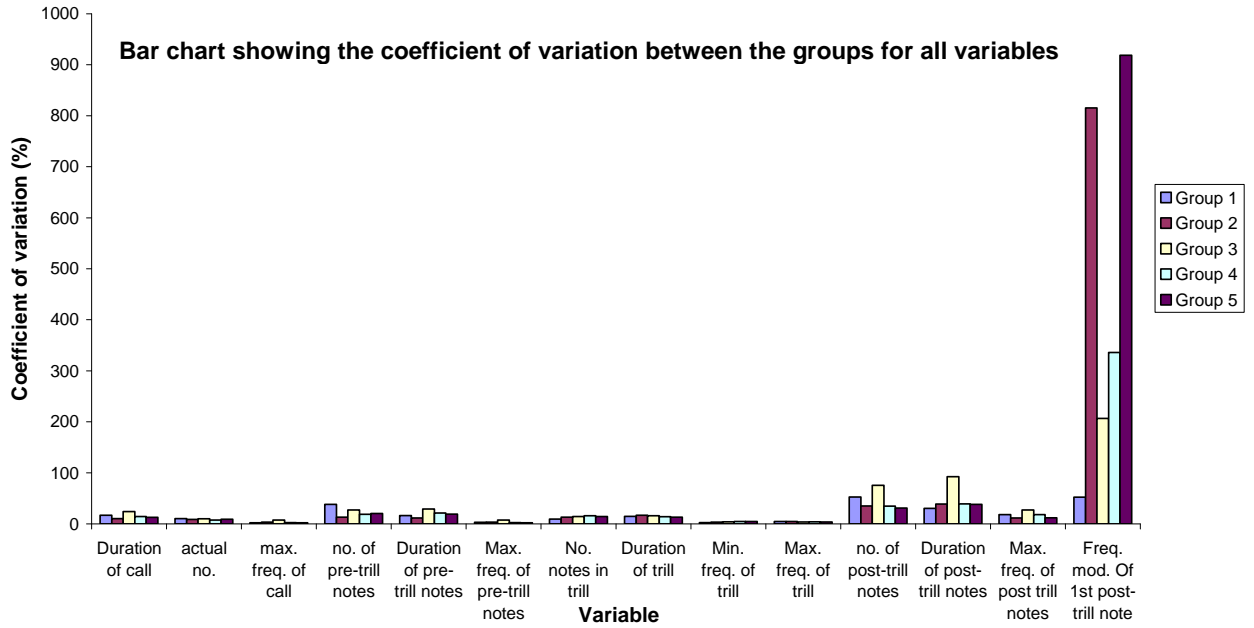


Figure 6.3: Graph comparing the coefficients of variation across the groups for all variables.

As can be seen in **Figure 6.4**, the coefficient of variation for most of the variables is reasonably low; the exceptions are for those variables that measure aspects of the post-trill element of the calls. This implies, with the exception of those variables just mentioned, that the range of figures for each of the remaining variables stays relatively stable and can therefore be considered an accurate reflection of the variables that have been measured.

However it must be mentioned that a low C.V. value can also be indicative of a small sample size so these results must be viewed with that in mind.

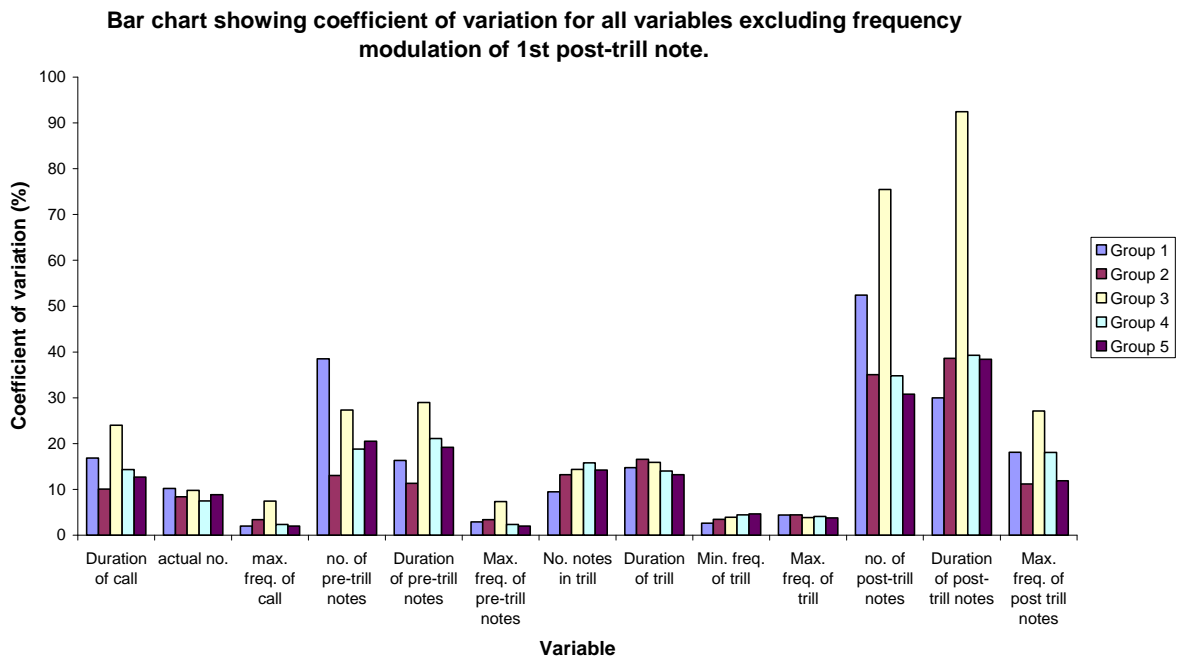


Figure 6.4: Graph comparing the coefficients of variation between the groups for different variables.

One possible explanation for the high variance for post-trill variables derives from the fact that these elements of the call are generally produced with decreasing amplitude. They are therefore not audible to great distance in the forest and most likely are inaudible to neighbouring groups. As a result of this Dallman & Geissmann (2001) found that these parts of the call are less likely to supply information on the identity of the calling individual, therefore the high variability is likely due to a lack of selection pressure for individuality in these elements of the call. This phenomenon has also been recognized in chimpanzee research (Mitani *et. al.*, 1996).

Predicted group membership and Discriminant function analysis

Given the highly variable nature of the post-trill elements of the calls, these statistics will be presented twice: Firstly, with the inclusion of the post-trill elements and secondly having excluded these elements. The effects on predicted group membership and the Discriminant function analysis will be explored.

Predicted group membership

Table 6.1 shows how well an individual can be assigned to its group based on the combination of variables used for the Discriminant function analysis. This is based on the results when the post-trill variables are included.

Table 6.10: Results from the Discriminant function analysis showing the percentage of individuals that were correctly assigned to their respective groups when using all variables.

Group	Predicted group membership (%)	Cross-validated predicted group membership (%)
1	100.0	100.0
2	94.8	94.8
3	100.0	100.0
4	87.5	81.3
5	85.7	85.7

As can be seen from the table, 93.5% of original grouped cases were correctly classified, 92.2% of cross-validated groups were correctly classified.

Table 6.2 shows how well individuals can be assigned to their groups based on the results when the post-variable trills are excluded.

Table 6.11: Results from the Discriminant function analysis showing the percentage of individuals that were correctly assigned to their respective groups when excluding the post-trill variables.

Group	Predicted group membership (%)	Cross-validated predicted group membership (%)
1	100.0	100
2	94.9	94.9
3	100.0	100
4	90.0	86.7
5	92.9	85.7

In this instance 94.8% of original grouped cases were correctly classified, rising to 93.5% for the cross-validated test.

This slight improvement in classification gives one basis for exclusion of the post-trill elements in the analysis.

Discriminant function analyses

Figure 6.5 below shows the individual canonical discriminant function diagram for the different groups when all variables are included.

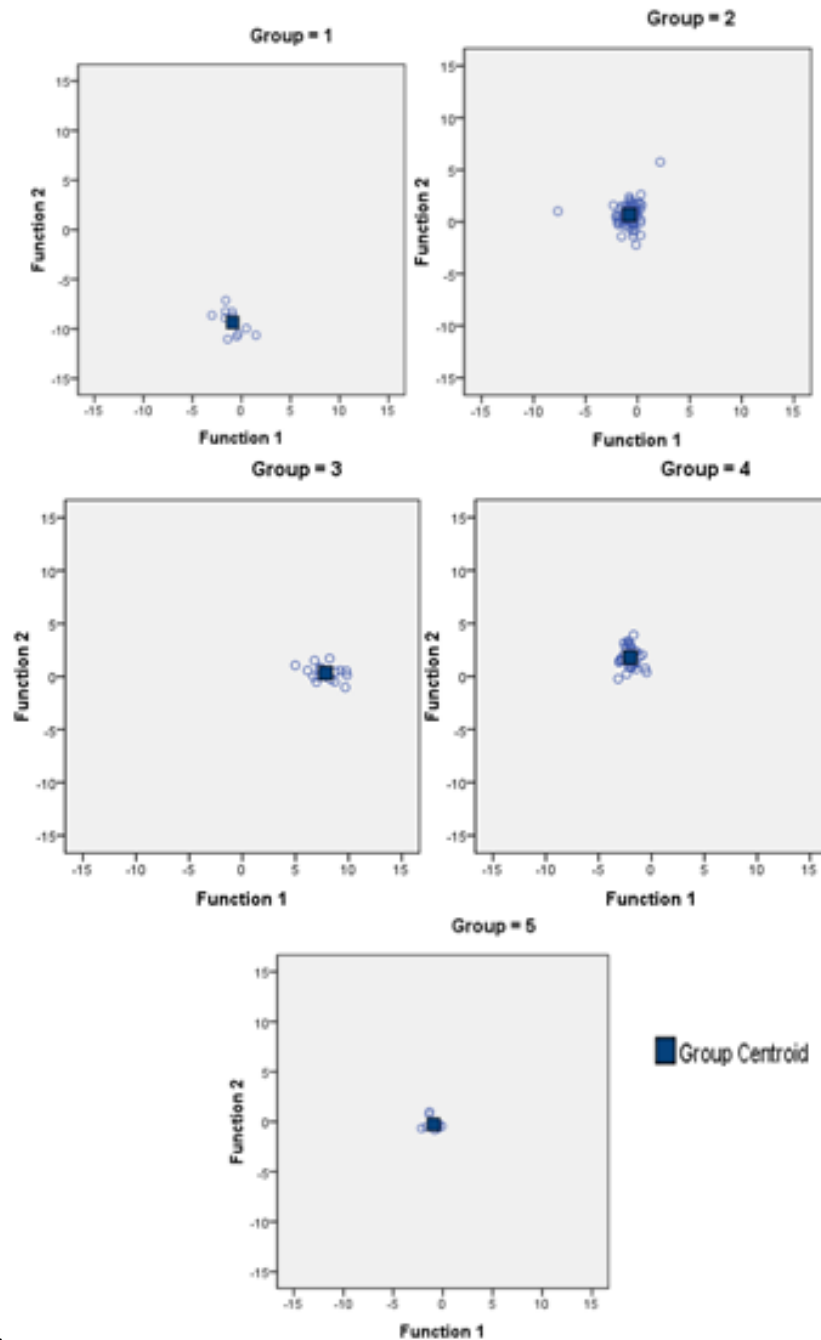


Figure 6.5: Canonical discriminant function diagrams showing the distribution of the calls around the group centroid.

This shows that the individuals cluster around the group centroid and that there are 2 calls in group 2 that are slightly less tightly clustered, implying that they are different in some way from the remaining group 2 calls. **Figure 6.6** shows the same canonical discriminant functions excluding the post-trill variables.

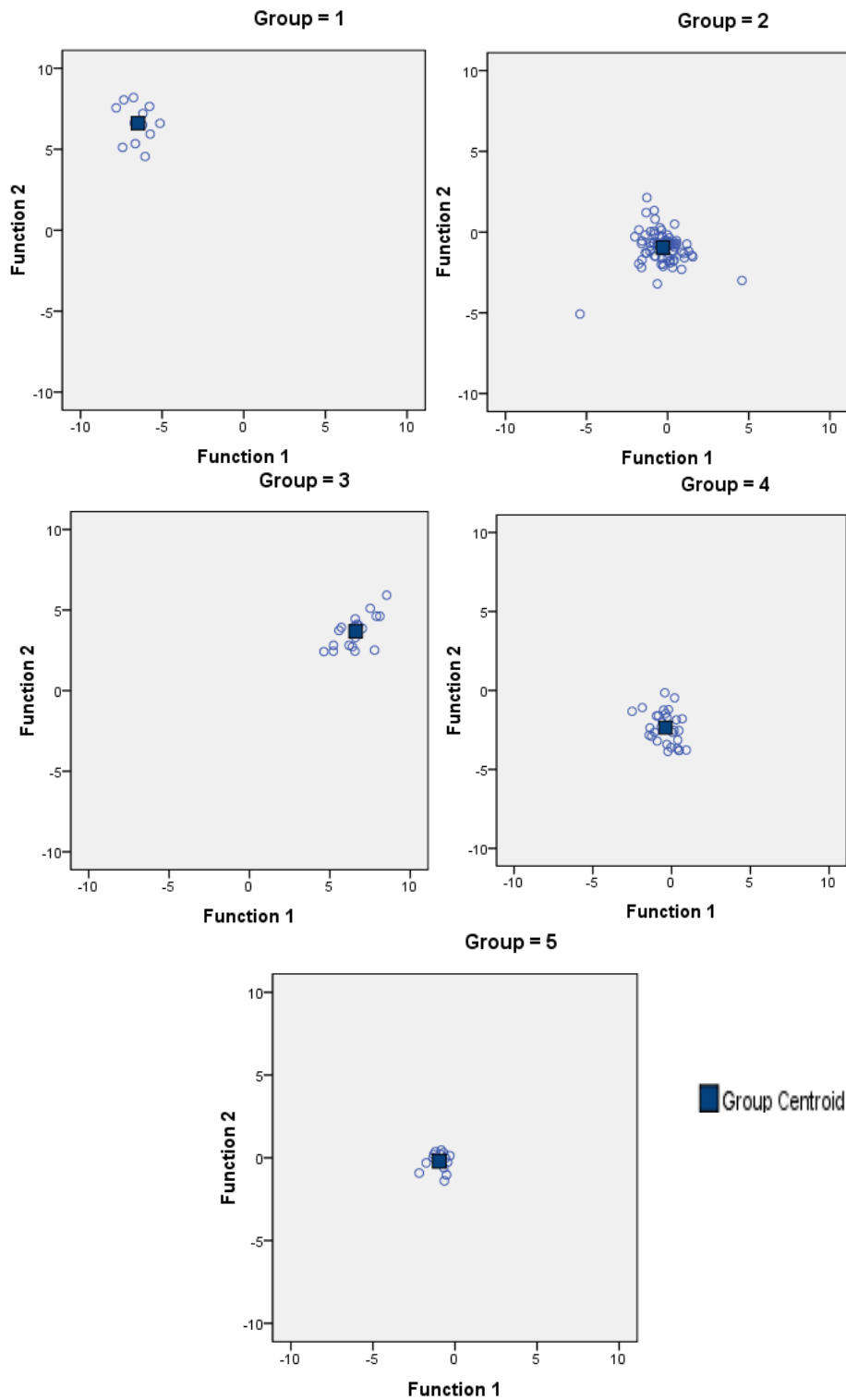


Figure 6.6: Canonical discriminant functions for the different groups excluding the post-trill variables.

This figure shows that the groups are similarly closely clustered around the centroid when the post-trill variables are excluded; therefore all further results shown are those with the exclusion of the post-trill variables.

Figure 6.7 below shows the canonical discriminant function for all groups having excluded the post-trill variables.

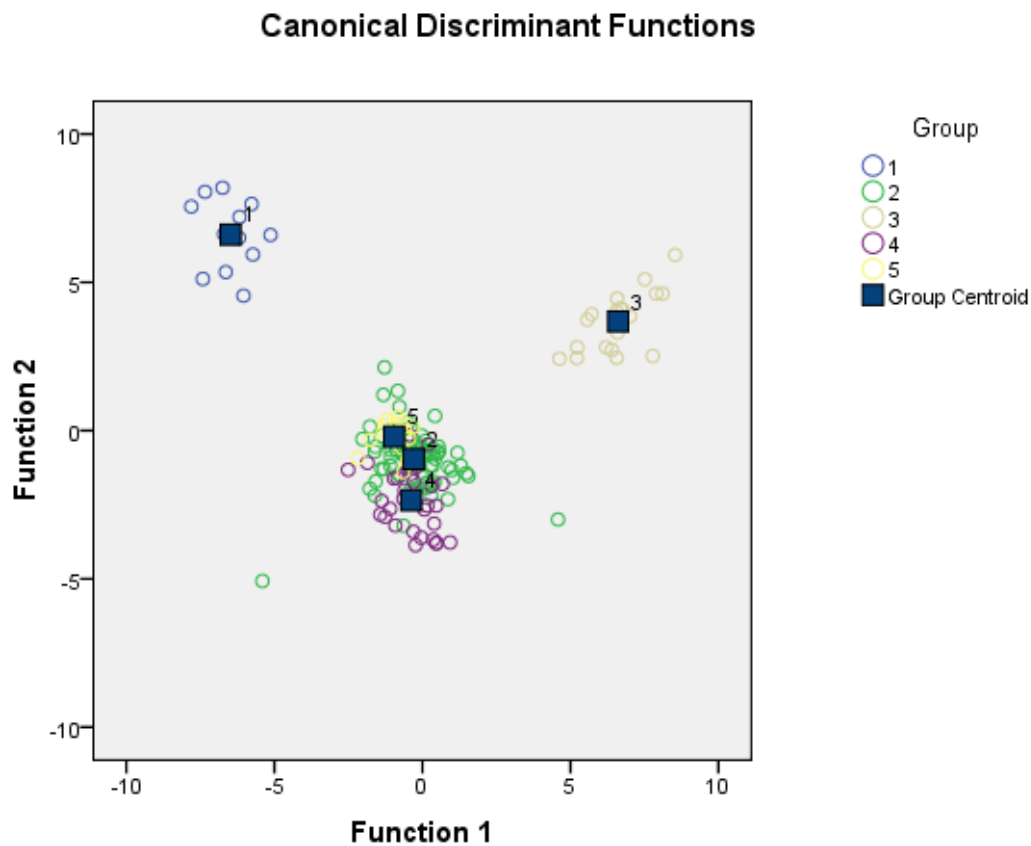


Figure 6.7: Canonical discriminant function diagram showing the clustering of individual calls within the groups and the relationship between the groups.

Figure 6.7 shows that groups 1 and 3 are the most vocally distinct as they cluster at the greatest distance. Groups 5, 2 and 4 cluster very close together although they are distinguishable with group 2 clustering in between the other groups. Group 2 has the most widely spaced calls.

7.0 Discussion

As a result of the lack of findings from the swamp forest, the discussion will be separated into two sections. The first section will discuss the findings from the primary rainforest and their conservation implications, the second section will discuss the possible reasons for the lack of findings in the peat-swamp forest and the implications of this on the conservation of the Kloss's gibbon.

The primary rainforest

Results of the canonical discriminant function test and mapping of theoretical home-range suggest that 5 distinct groups were studied for this research and that these groups can be identified and separated based on their vocal characteristics.

By enabling discrimination between individuals this study raises the possibility of studying Kloss's gibbons on an individual basis; something previous research has proven difficult on the basis of their uniform morphology across all age and sex classes.

This new understanding of Kloss's gibbon vocalisations can enable more accurate population censuses to be undertaken as different individuals and/or groups can be isolated and counted without the fear of duplication of results.

Finding 5 distinct groups in relatively close proximity also underlines the importance of the Peleonan forest as Kloss's habitat. This relatively small area harbours a high density of all of the endemic Mentawai primates and yet still lacks formal protection from the Indonesian government. Despite a near-constant research presence in Pungut the area is still under threat from encroachment and hunting and with no formal protection this can only be expected to continue.

The swamp forest

As no gibbons were encountered in the peat-swamp forest this section will address the possible reasons why, the conservation implications of these reasons, and subsequent recommendations for preservation of this species and its habitats.

The reasons are divided as follows:

- Seasonal use of the peat-swamp habitat
- Behavioural episode caused by recent natural disasters
- Human encroachment within the habitat
- Possible over-estimation of gibbon abundance due to a number of factors (such as human error etc.)

Seasonal use of the Peat-Swamp habitat

The only previous research undertaken in this area was Quinten (2008), who completed the fieldwork element of the study in 2007. This research was undertaken during August and September, towards the end of the dry season on the Mentawai. During this time the food availability in the primary rainforest is at its lowest, previous research has documented that Kloss's gibbons can have very flexible diets, changing their food choices based on the composition of the forest (Whittaker, 2005a). During these periods of low food abundance many primates, including several gibbon species, are known to use fig species as an alternative food source. This is because fig species have an asynchronous fruiting cycle i.e. the trees do not all fruit at the same time; therefore they are able to provide food the whole year round (Cheyne, 2010).

It is possible therefore, that during times of relatively low food abundance, the Kloss's gibbons that normally inhabit the primary rainforest on the periphery of the swamp, begin to forage further into the swamp in order to make use of the year-round availability of fruits such as figs and those of the *Annonaceae* family.

This theory was substantiated by conversations with people from the local village who say that the Bilou move during the dry season from June to September and are only heard in the swamp during these seasons and they are observed to preferentially eat figs during this time (Pak Tarsan, *Pers. Comm.*).

Behavioural episodes caused by natural disasters

Quinten (2008) completed his research both during, and in the immediate aftermath of a big earthquake on the Mentawai archipelago. Very little research exists on the documentation of non-human primate response to seismic activity. Snarr (2005) presents the first dataset on a non-captive population of primates. This research documents the behaviour in the immediate aftermath of the earthquake but not in the subsequent days. Amongst the behaviours listed as responses to the earthquake, the primates that were studied called extensively immediately after the earthquake, calling periods such as these will generate false impressions of primate density and abundance as an individual may call from one location and then move and continue to call from other locations. Although this is the least likely of the scenarios, it is worthwhile to note that seismic activity could play a large part in the Kloss's habitat choice as earthquakes are relatively common within the Mentawai archipelago and are therefore likely to affect habitat choice and behavioural patterns.

Human encroachment within the habitat

Deforestation has already been identified as the major threat to Kloss's gibbon populations across their habitat range. **Figure 7.1** below shows the extent of degradation and encroachment into the peat-swamp area of the Peleonan forest from 1988 to the present.

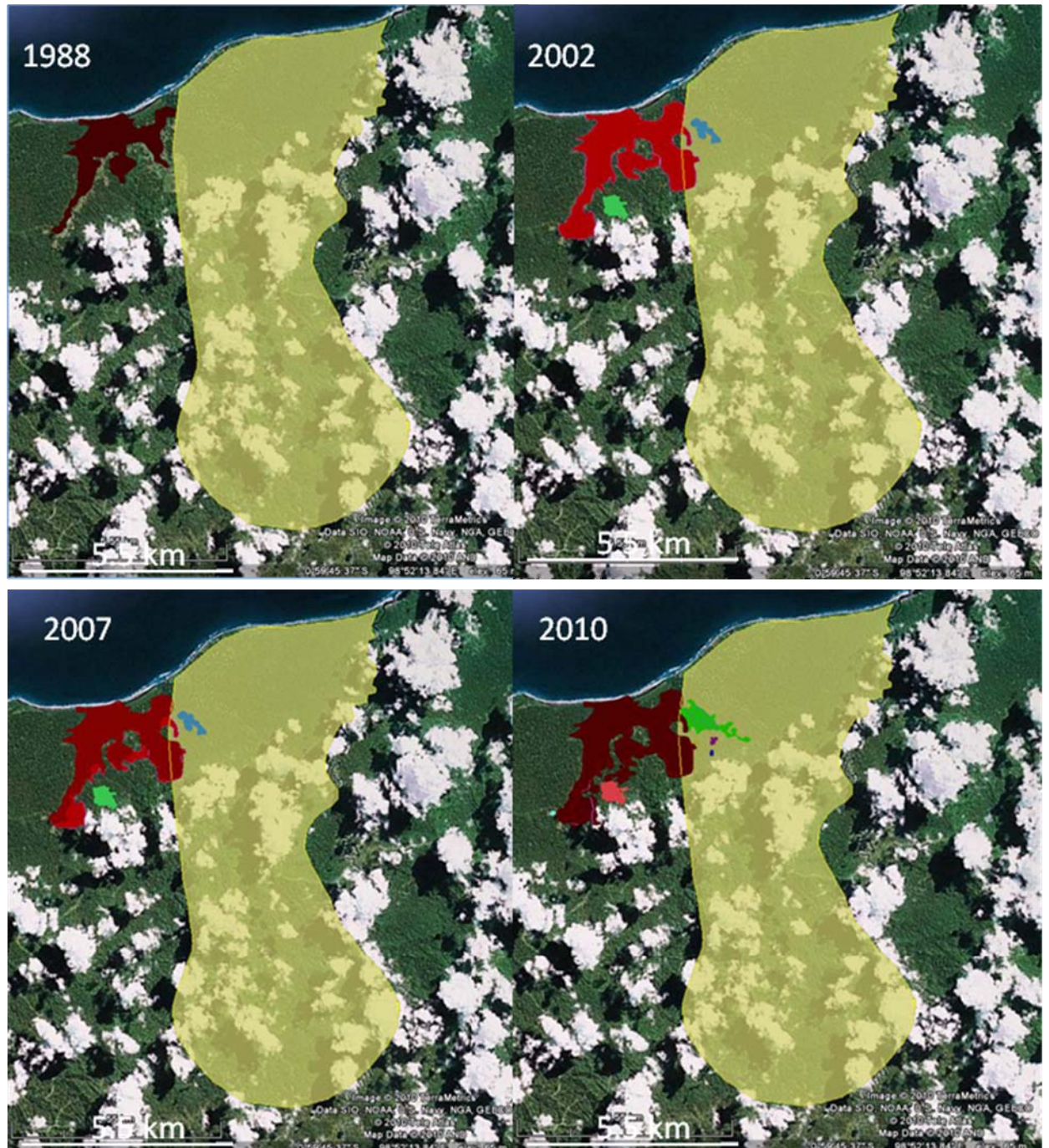


Figure 7.8: Map showing encroachment into the Peleonan forest area from a nearby town called Sikapogna. The large yellow area denotes the boundary of the Peleonan forest, the smaller red, green, blue and pink areas show the extent of the deforestation. Deforestation data used with permission, Quinten (2008), map used from Google Earth Pro (2010).

As can be seen from the map, the encroachment into the Peleonan forest has been significant. Several times during the course of this research chainsaws were heard from the swamp forest so it is likely that this disturbance has caused a movement of gibbons away from the fringes of the logged areas, and possibly out of the swamp altogether. **Figure 7.2** shows the extent of the logging activities with respect to the Peat Swamp forest area.

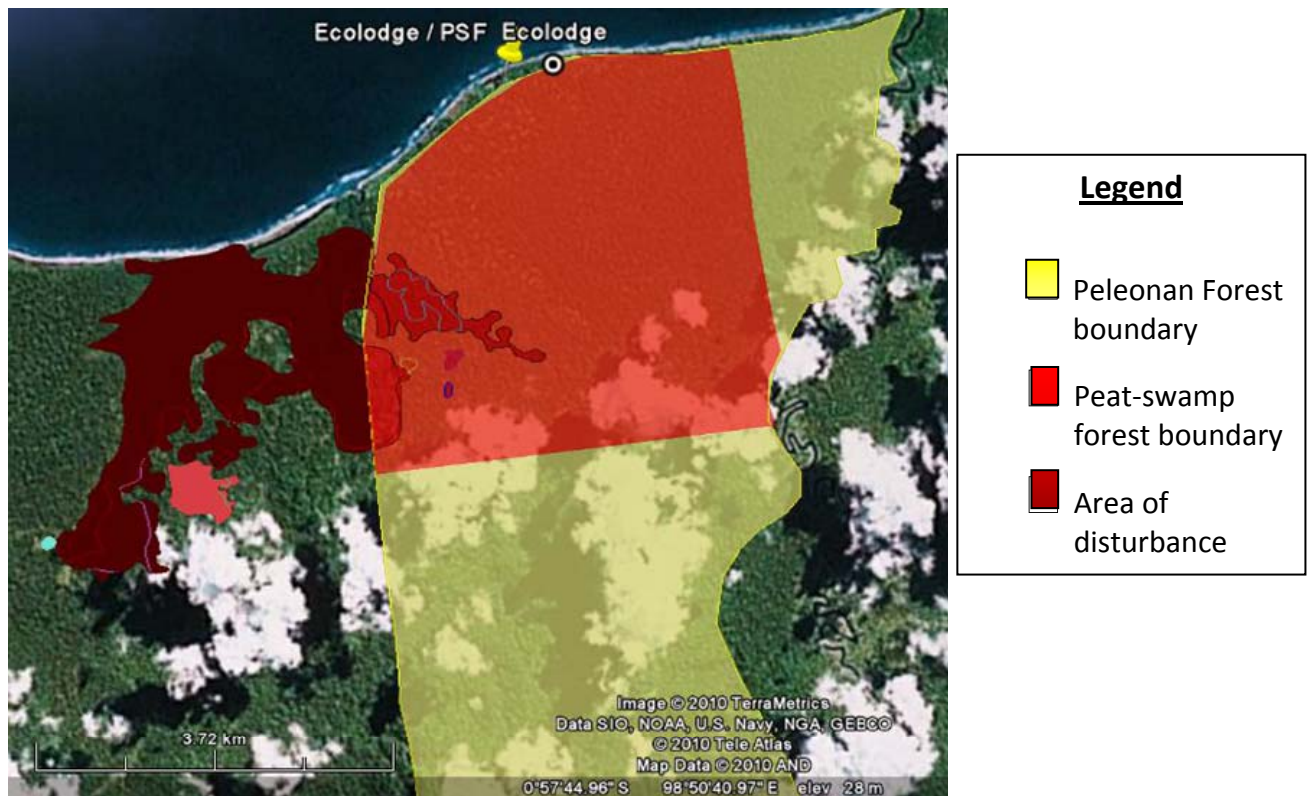


Figure 7.9: The extent of degradation with respect to the peat-swamp forest.

As can be seen from the map, despite the fact that the majority of habitat destruction has occurred on the borders of the Peat-Swamp ecosystem, the logging has encroached up to 2km in some areas, effectively cutting the peat-swamp forest in half. The Peleonan forest is bordered on the other side by a river and therefore the gibbons would be either 'trapped' in a smaller area between the logged areas, the river and the sea; instead it is likely that they have been driven into the surrounding primary rainforest.

Over-estimation of gibbon abundance

Quinten (2008) observed 3 gibbon groups, and encountered many more audially in the peat swamp forest habitat whilst conducting research in 2007. For the reasons listed above it is possible that these encounters were either an anomaly resulting

from seasonal changes or seismic activity. However, the estimated density of the gibbons inhabiting the swamp is interesting in itself. Quinten (2008) states that the density of Kloss's gibbons found in this habitat would be likely to result in an estimated 35 individuals inhabiting the peat-swamp forest. This figure is very high considering the fact that the peat-swamp forest is generally considered inappropriate habitat for gibbons because of the sparse canopy. Whilst conducting the research in the swamp forest I observed that the indigenous Mynah bird species *Gracula religiosa* mimics the loud call of the males. This has been documented in the past (Archawaranon, 2005), and has also previously been noted on Siberut (Tenaza, 1976).

It is possible that the density of the gibbons was over-estimated because of mis-identification of the Mynah Bird calls. Two factors support this theory:

- 1) Quinten (2008) did not study gibbons exclusively, and therefore it is possible, however unlikely, that the mis-identification could have happened.
- 2) Male gibbons always call before 06:30hr (sunrise) and are drowned out by the insect morning chorus after this time. Quinten (2008) only conducted surveys between 07:00hr and 17:30hr and therefore would never have encountered the male gibbons whilst they were calling. It is therefore possible that, where the gibbons were 'encountered' by their calls, it was in fact the mimicry of the Mynah birds that was surveyed instead.

Even though gibbons were visually encountered by Quinten, it is possible that the density of the gibbons in the swamp was overestimated as a result of the mis-identification of Mynah bird vocalisations.

It is therefore possible that the population estimates for Kloss's gibbons are larger than they should be as a result of this mis-identification.

It is also likely that the estimated extent of viable habitat is greater than that actually in use as deforestation and encroachment force gibbons to recede further into primary forests across the Mentawai.

Consequences of these findings for the conservation of Kloss's Gibbons

The over-estimated of Kloss's gibbons in swamp habitats, as well as the potential over-estimated area of suitable habitat for the gibbons suggests that current population estimates for Kloss's gibbons could be exaggerated, which would suggest that these populations are even more endangered than previously thought.

Whittaker (2005b) estimates that nearly 3000km² of adequate gibbon habitat remains on the Mentawais, this figure could be drastically reduced if similar logging situations are occurring across the rest of the Mentawais.

Current proposed management strategies

It has been claimed by many conservation biologists that in order to achieve truly affective conservation one must focus on levels of organisation higher than that of population or individual (Nijman, 2001); it is argued by as many that single species can, and do play important roles in acting as indicators for monitoring the health of ecosystems and therefore research such as this will continue to be vital to inform management strategies.

Whittaker (2005a) proposed several management strategies for the Kloss's gibbon, outlined in chapter 2.5, but as yet these suggestions have not been put in to practice; and without further international presence in the Mentawais (for research purposes or otherwise) it is likely that the populations of endemic species within this area will continue to decline.

8.0 The future of Kloss's gibbon conservation

Threats

The major threats to the Kloss's gibbon have already been identified; illegal logging causing habitat destruction has long been considered the greatest of these. However, greater threats are ever closer on the horizon.

The palm oil industry in Indonesia is an ever expanding one and Indonesia has recently overtaken Malaysia and is now the world's greatest producer of palm oil; it was forecast to produce an estimated 18.3 million metric tonnes of Palm Oil in 2008/2009 (Crutchfield, 2007). Recently new regions have been made available to the palm oil industry across Indonesia but particularly in West Sumatra. In 1996 it was announced that land had been made available on the Mentawai for this purpose (Quinten, 2008). This unchecked habitat destruction will likely overtake logging as the major factor influencing available gibbon habitat in the future.

Enforcement

The enforcement of current laws protecting the Kloss's gibbon is inadequate. Greater emphasis on the importance of this role, and international pressure demanding better enforcement are likely the only demands that could galvanise the Indonesian government into action.

This could be coupled with community re-development, capacity building and the provision of jobs for individuals previously engaged in illegal activities.

Siberut National Park

Despite being the only formally protected area on the Mentawai Islands, the SNP still experiences poor law-enforcement. As a result there is still a great deal of hunting and forest product extraction within the park boundaries (Whittaker, 2005b).

As this is potentially the last-remaining viable stronghold for the Kloss's gibbon, conservation efforts must be focused on strengthening enforcement measures within SNP before they look to the establishment of further reserves.

Sipora and the Pagais

Whittaker (2005b) suggests that the areas already gazetted by Tenaza (1988) and Fuentes (1997) as future reserves to be formally protected have already been logged. This re-iterates the importance of SNP as the last-remaining stronghold, not

just for the Kloss's gibbon, but for all of the Mentawai primates. New reserves on these southern islands, while desirable, must surely now take a back seat if the successful protection of these primates is ever to be achieved.

The Peleonan forest of northern Siberut

As a unique habitat within the Mentawai formal protection of the Peleonan forest has been recommended because of the high density of all Mentawai primates that exist within its borders, it also has unusually high biodiversity for other species, such as birds and butterflies, and supports large populations of others.

This area also has an established research presence and therefore the enforcement of laws that would formally protect it would be marginally easier in this area than that of the SNP.

Education and Sustainable development

Capacity building via conservation education and sustainable development has long been touted as the best option for long-term viability for conservation projects. Conservation can only truly be called successful if local communities are involved at a grass-roots level thereby ensuring the sustainability of the project.

The SCP has gone some way to achieve this end in the Peleonan forest, with all guides being employed from the local village and education programmes as well as services being provided by all visiting researchers and by the Indonesian management staff on-site.

Ecotourism

Despite eco-tourism being defined as culturally and ecologically sensitive travel that is educational and low-impact that also benefits both the local communities and the host countries (Buckley, 2009), it is one of the fastest-expanding global industries, growing at an estimated 10-30% each year and accounting for 1 in 5 tourists (Ananthaswamy, 2004). The guidelines set down for the preservation of the nature that is intended to be experienced are often not followed. Several scientists believe that the stress that tourists place on an ecosystem, and indeed on the animals if they are being closely observed, is directly causing behavioural differences and in some cases has been cited as the cause of premature death of some animals (Ananthaswamy, 2004).

It is for this reason that eco-tourism, although a potentially viable option for the long-term conservation of Mentawai species, should probably not be considered until further protection of the habitat has been achieved.

9.0 Autocritique

The research in the primary rainforest site was achieved as expected, although the method had to be somewhat adapted according to the weather conditions. The lack of gibbon encounters in the swamp forest was both unexpected and saddening. Although it is possible that this could be accounted for by seasonality of habitat use, my instinctive feeling was that a borderline habitat was pushed into being unsuitable by the seemingly unstoppable march of humans into the forest habitats.

Although important to acknowledge and accept from a conservation management point of view, it is the most regrettable finding of this research.

I was not expecting to be able to statistically differentiate between different groups within a forest habitat so that result is particularly pleasing, although it would stand up better with more calls from each individual and more groups from around the area to ensure that it is not simply an artefact of a relatively small sample size.

In terms of future research it would be interesting to apply the same principles to other areas within the same forest type and other habitats on Siberut to see if the differences between groups of an area are as distinct as between the average characteristics of two areas. This could then be expanded to Sipora and the Pagais, furthering both this research and that of Waller (2005) and Keith (2005); hopefully with the aim of being to identify and study groups of Kloss's gibbons without the need for invasive monitoring techniques such as radio-collaring.

References

- Ananthaswamy, A., 2004. Massive growth of ecotourism worries biologists [online]. New Scientist: United States of America.
<http://www.newscientist.com/article/dn4733-massive-growth-of-ecotourism-worries-biologists.html?full=true>, accessed 06/06/10.
- Archawaranon, M., 2005. Vocal Mimicry in Relation to Social Dominance in Hill Mynah *Gracula religiosa*. *Journal of Biological Sciences*, 5(6), pp. 771-775.
- Brandon-Jones, D., 1996. The Asian Colobinae (Mammalia: Cercopithecidae) as indicators of Quaternary climate change. *Biological Journal of the Linnean Society*. 59, pp.327-350.
- Brandon-Jones, D., 1998. Pre-glacial Bornean primate impoverishment and Wallace's line, pp. 393-404. IN Hall, R., Holloway, J.D., (eds.) *Biogeography and Evolution of Southeast Asia*. Leiden, Netherlands: Backhuys Publishers.
- Brandon-Jones, D., Eudey, A.A., Geissmann, T., Groves, C.P., Melnick, D.J., Morales, J.C., Shekelle, M., Stewart, C.B., 2004. Asian Primate Classification. *International Journal of Primatology*. 25(2), pp. 97-164.
- Buckley, R., 2009. *Ecotourism: Principles and Practices*. CABI Tourism Texts: Australia.
- Campbell, C., Andayani, N., Cheyne, S., Pamungkas, J., Manullang, B., Usman, F., Wedana, M., Traylor-Holzer, R. (eds.), 2008. *Indonesian Gibbon Conservation and Management Workshop, Final Report*. 20-22 February 2008. Sukabumi, West Java, Indonesia.
- Chapman, C.A., 2005. Primate Seed Dispersal: Coevolution and Conservation Implications. *Evolutionary Anthropology*. 4(3), pp.74-82.
- Cheyne, S.M. 2010. Behavioural ecology and socio-biology of gibbons (*Hylobates alibarbis*) in a degraded peat swamp forest, pp. 121-156. IN Supriatna, J., Gursky, S.L., (eds.) *Indonesian Primates (Developments in Primatology: Progress and Prospects)*. UK: Springer Publishing.
- Cheyne, S.M., Thompson, C.J.H., Phillips, A.C., Hill, R.M.C., Limin, S.H., 2008. Density and population estimate of gibbons (*Hylobates albibarbis*) in the Sabangu catchment, Central Kalimantan, Indonesia. *Primates*. 49, pp.50-56.
- Crutchfield, J., 2007. Indonesia: Palm Oil Production Prospects Continue to Grow [online]. USDA: United States of America,

http://www.pecad.fas.usda.gov/highlights/2007/12/Indonesia_palmoil/, accessed 05/06/10.

Dallmann, R., Geissmann, T., 2001. Individuality in the female songs of wild silvery gibbons (*Hylobates moloch*) on Java, Indonesia. *Contributions to zoology*. 70, pp.41-50.

Fuentes, A., 1997. Current Status and Future Viability for the Mentawai Primates. *Primate Conservation*. 17, pp.111-116.

Fuentes, A., 2002. Monkeys, humans and politics in the Mentawai Islands: no simple solutions in a complex world, pp.187-207. IN Fuentes, A., Wolfe, L.D., (eds.) *Primates Face to Face: Conservation Implications of Human-Nonhuman Primate Interconnections*. New York: Cambridge University Press.

Geissmann, T., 2007. Status Reassessment of the gibbons: Results of the Asian Primate Red List Workshop 2006. *Gibbon Journal*. 3, pp.5-15.

Google Earth, 2010. Google Earth maps. Google: United States of America. [accessed 07/06/10]

Haimoff, E.H., Tilson, R.L., 1985. Individuality in the Female Songs of Wild Kloss' Gibbons (*Hylobates klossii*) on Siberut Island, Indonesia. *Folia Primatologica*. 44, pp.129-137.

IGCMW, 2008. International Gibbon Conservation and Management Workshop. Sukumbumi, West Java; Indonesia. pp. 1-96.

IUCN, 2008. The Red List [online].

www.iucnredlist.org/apps/redlist/details/10547/0. Accessed 06/06/10.

Keith, S.A., 2005. *Vocal Diversity of Female Kloss's Gibbons (Hylobates klossii) in the Mentawai Islands, Indonesia*. Msc Thesis: Oxford Brookes.

Landau, S., Everitt, B.S., 2004. *A Handbook of Statistical Analyses using SPSS*. Boca Raton, Florida: Chapman & Hall/CRC CRC Press LLC.

Mackinnon, K.S. 1984. The Distribution and Status of Gibbons in Indonesia, pp. 16-18. IN Chivers, D.J., Preuschoft, H., Brockelman, W., Creel, N., (eds.) *The Lesser Apes: Evolutionary & Behavioural Biology*. Edinburgh: Edinburgh University Press.

Marshall, A.J., Leighton, M., (2006) How does food availability limit the population density of white-bearded gibbons? pp.313-335. IN Hohmann, G., Robbins, M.M., Boesch, C. (eds.) *Feeding Ecology in Apes and Other Primates. Ecological, Physical and Behavioural Aspects*. Cambridge: Cambridge University Press.

Meehl, G.A., Washington, W.M., Collins, W.D., Arblaster, J.M., Aixue, H., Buja, L.E., Strand, W.G., Teng, H., 2005. How Much More Global Warming and Sea Level Rise? *Science*. 307(5716), pp.1769 – 1772.

Ministry of Forestry for the Republic of Indonesia (MFRI), 2008. Siberut National Park [online]. http://www.dephut.go.id/INFORMASI/TN%20INDO-ENGLISH/siberut_NP.htm, accessed 05/06/2010.

Mitani, J.C., Gros-Louis, J., Macedonia, J.M., 1996. Selection for acoustic individuality within the vocal repertoire of wild chimpanzees. *International Journal of Primatology*. 17, pp.569-583.

Morton, E.S., 1975. Ecological sources of selection on avian sounds. *American Naturalist*. 109, pp.17-34.

Nijman, V. 2001. Effects of Behavioural Changes Due to Habitat Disturbance on Density Estimation of Rain Forest Vertebrates, as Illustrated by Gibbons (Primates: Hylobatidae), pp.33-42. IN Hillegers, P.J.M., de Longh, H.H. (eds.) *The balance between biodiversity conservation and sustainable use of tropical rain forests*. Wageningen: The Tropenbos Foundation.

Quinten, M., 2008. *Survey of the Primate Community of Peat Swamp Forests on Siberut, Mentawai Islands (Indonesia)*. MSc Thesis: Georg-August Universitat Gottingen, Germany & Lincoln University, Christchurch, New Zealand.

Ricklefs, M.C., 1993. *A History of Modern Indonesia Since c.1300*. Stanford: Stanford University Press.

Schneider, C., Hodges, K., Fischer, J., Hammerschmidt, K., 2008. Acoustic Niches of Siberut Primates. *International Journal of Primatology*. 29, pp.601-613.

Snarr, K.A., 2005. Seismic activity response as observed in mantled howlers (*Alouatta palliate*), Cuero y Salado Wildlife Refuge, Honduras. *Primates*. 46, pp. 281-285.

Stephens, R.W.B., Bate, A.E., 1966. *Acoustics and Vibrational Physics*. London: Arnold

Tenaza, R.R., 1975a. The Functions and taxonomic implications of singing among Kloss gibbons (*Hylobates klossii*) in the Mentawai Islands. *American Journal of Physical Anthropology*. 42(2), pp.334.

Tenaza, R.R., 1975b. Territory and Monogamy Among Kloss' Gibbons (*Hylobates klossii*) in Siberut Island, Indonesia. *Folia Primatologica*. 24, pp.60-80.

Tenaza, R.R., 1976. Wild Mynahs Mimic Wild Primates. *Nature*, 259, pp561.

- Tenaza, R.R., 1991. Conservation of Mentawai Island Primates. *Primate Today*, pp55-58.
- Tenaza, R.R., Hamilton, W.J.III., 1971. Preliminary Observations of the Mentawai Islands Gibbon, *Hylobates klossii*. *Folia Primatologica*. 15, pp.201-211.
- Tenaza, R.R., Mitchell, A.H., 1985. Summary of Primate Conservation – problems in the Mentawai Islands. *Primate Conservation*. 6, pp.36-37.
- Tenaza, R.R., Tilson R.L., 1977. Evolution of Long-Distance Alarm Calls in Kloss' Gibbon. *Nature*. 268, pp.233-235.
- Tenaza, R.R., Tilson, R.L., 1985. Human Predation and Kloss' Gibbon (*Hylobates klossii*) Sleeping Trees in Siberut Island, Indonesia. *American Journal of Primatology*. 8, pp.299-308.
- Tilson & Tenaza, 1982. Interspecific Spacing Between Gibbons (*Hylobates klossii*) and Langurs (*Presbitis potenziani*) on Siberut Island, Indonesia. *American Journal of Primatology*. 2, pp.355-361.
- Waller, M.S., 2005. *Vocal Diversity of the male Kloss's gibbon (Hylobates klossii) in the Mentawai Islands, Indonesia*. MSc Thesis: Oxford Brookes.
- Waser, P.M., Waser, M.S.Z., 1977. Experimental studies of primate vocalisation: Specialisations for long-distance propagation. *Zeitschrift fur Tierpsychologie*. 43, pp.239-263.
- Whittaker, D.J., 2005a. *Evolutionary Genetics of Kloss's Gibbons (Hylobates klossii): Systematics, Phylogeography, and Conservation*. PhD Thesis: The City University of New York.
- Whittaker, D.J., 2005b. New population estimates for the endemic Kloss's gibbon *Hylobates klossii* on the Mentawai Islands, Indonesia. *Oryx*. 39(4), pp.1-4.
- Whittaker, D.J., Morales, J.C., Melnick, D.J., 2003. Conservation Biology of Kloss's gibbons (*Hylobates klossii*). AAPA Convention, Abstracts pp.224.
- Whittaker, D.J., Morales, J.C., Melnick, D.J., 2007. Resolution of the *Hylobates* phylogeny: Congruence of mitochondrial D-loop sequences with molecular, behavioural, and morphological data sets. *Molecular Phylogenies and Evolution*. 45, pp.620-628.
- Whitten, A.J., 1980. *The Kloss Gibbon in Siberut Rain Forest*. PhD Thesis: University of Cambridge.

Whitten, A.J., 1982a. Diet and Feeding Behaviour of Kloss Gibbons on Siberut Island, Indonesia. *Folia Primatologica*. 37, pp. 177-208.

Whitten, A.J., 1982b. Home Range Use By Kloss Gibbons (*Hylobates klossii*) on Siberut Island, Indonesia. *Animal Behaviour*. 30, pp.182-198.

Whitten, A.J., 1982c. *The Gibbons of Siberut*. London: J.H. Dent & Sons Ltd.

Whitten, A.J., 1982d. The Ecology of Singing in Kloss Gibbons (*Hylobates klossii*) on Siberut Island, Indonesia. *International Journal of Primatology*. 3(1), pp.33-51.

Whitten, A.J., 1984a. Defense by Singing: Great calls and songs of the Kloss gibbon, pp.420-421. IN MacDonald, D., (ed.) *The encyclopedia of mammals, vol. 1*. London: Allen and Unwin.

Whitten, A.J., 1984b. Ecological Comparisons between Kloss Gibbons and other Small Gibbons. pp.219-227. IN Preuschoft, H., Chivers, D.J., Brockelman, W., Creel, N. (eds.) *The Lesser Apes: Evolutionary and Behavioural Biology*. Edinburgh: Edinburgh University Press.

Ziegler, T., Abegg, C., Hodges, K., 2004. The "Siberut Conservation Project" – Field Research embedded in a Conservation Programme. *IPS Bulletin*. 9, pp1-10.

Appendix 1 – The different forest types on Siberut and their structural ecology

Forest Type	Description
Tropical Lowland Evergreen Rainforest	Either <i>Dipterocarpus</i> -dominated or mixed forest, this is the most abundant forest type on Siberut. It occurs inland.
Beach Forest	Can be sub-divided into accreting or beach wall forests, only found coastally.
Mangrove Forest	Grow in permanent standing saltwater.
Brackish water forest	Mature forests are dominated by <i>Brugiera gymnorhiza</i> , accreting forests are dominated by <i>Nypa fruticans</i> .
<i>Alangium cf ridleyi</i> / <i>Lophopetalum javanicum</i> swamp forest	These forests are only occasionally / seasonally wet and have mineral soils.
<i>Stemonurus secundiflorus</i> / <i>Terminalia phellocarpa</i> swamp forest	These swamp forests are permanently wet and have oligotrophic peat soils.

Appendix 2 – GPS data for the research sites and listening posts

Site	GPS coordinates	Altitude (metres above sea level)
Pungut	S 1 01.063 E 98 50.286	20
Pale Leuk Leu	S 0°56'21.71" E 98°49'44.19"	22
Group 1	S 1 01.052 E 98 50.275	63
Group 2	S 1 00.995 E 98 50.747	72
Group 3	S 1 01.554 E 98 50.322	127
Group 4	S 1 01.003 E 98 50.678	64
Group 5	S 1 00.757 E 98 50.090	103

Appendix 3 – Full equipment and software listEquipment

Item	Model
GPS	Garmin 60 CSX
Recorder	Marantz Solid State PMD661
Microphone	Sennheiser ME66 shotgun unidirectional microphone
Wind shield	MZW-66 pro-wind screen
Compass	unknown

Software

Avisoft SASLab Pro Bioacoustic software

GoogleEarth 5.1

GoogleEarth Pro

ArcGIS 9.3

Garmin MapSource

Microsoft Word 2007

Microsoft Excel 2007

Appendix 4 – transect map of Pungut research station

