Daily ranger-based symptom observations and health monitoring of habituated mountain gorillas (*gorilla beringei beringei*) in Bwindi impenetrable national park, Uganda

BY

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DECLARATION

I, **Benard Jasper Ssebide**, declare that this study is original and has never been published or submitted for any degree award or any other award to any other university or institution.

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DEDICATION

To Sylvia, James, and baby Jesse for the patience and moral support.

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ABBREVIATIONS AND ACRONYMS

%	-	Percentage
BINP	-	Bwindi Impenetrable National Park
BMCA	-	Bwindi / Mgahinga Conservation Area
BVM	-	Bachelor of Veterinary Medicine
e.g.	-	For example
i.e.	-	that is to say
ICCN	-	Institute Congolese de Conservation de la Nature
Mak.	-	Makerere University, Kampala
MGNP	-	Mgahinga Gorilla National Park
MGVP	-	Mountain Gorilla Veterinary Project
NA	-	Not Applicable
ORTPN	-	Office Rwandese du Tourisme des Parc, Nationaux
PNV	-	Parc Nationale des Volcans
PNVi	-	Parc Nationale des Virunga
RBDC	-	Ranger Based Data Collection
UD	-	Utilization distribution
UWA	-	Uganda Wildlife Authority
DRC	-	Democratic Republic of Congo
SB	-	Silver-back
BB	-	Black-back
AF	-	Adult female
SA / Juv	-	Sub adult / Juvenile
In	-	Infant

ABSTRACT

It is often hypothesized that transmission of human diseases to apes is a (if not the) major threat to species survival hence the need for a systematic approach to health data collection yielding solid evidence on which to base intervention strategies for reducing disease transmission. This research was aimed at identification and assessment of clinical parameters among habituated mountain gorillas of Bwindi Impenetrable National Park. Basic health data was collected by the UWA rangers (trackers and guides) using daily clinical observation forms.

There were 1825 potential gorilla group observation days for all the five groups of which 1482 (81.2%) gorilla group observation days were recorded. On average, at least 15 people enter the park per day to track Habinyanja, Mubale and Rushegura groups while an average of 11 people enter to track Nkuringo group of which tourists generally form 40%. An average tourist occupancy rate of 80% was observed in Habinyanja, Mubale and Rushegura groups while in Nkuringo group, an occupancy rate of 56.2% was observed. Fluctuations in the number of visitors were observed with November, April, and May registering fewer visitors than other months and throughout the study period, Nkuringo group significantly had fewer visitors than other tourists groups.

A total of 18018 individual gorilla observations were made out of the potential (if every individual gorilla were seen each observation day) 22939 resulting into an overall observability of individual gorillas of 78.5%. Kyaguliro group individuals were seen most with 96.6% and Nkuringo group individuals were seen least with 66.8%. While by age / sex class, silverbacks were seen most at 93.8% and black-backs were seen least at 70.2%.

Based on the gorillas seen, the body system was observed most with 98.6% (n=18018). The general activity was observed in 98.2%, the respiratory system in 96.7%, the skin / hair in 96.8%, head discharge in 87.3%, other discharge in 35.6%, and the stool was observed least in 3.9% of gorillas seen.

During the study period, 86 abnormal observations were made, out of which 68.6% were wounds and cuts on the integumentary system (skin and hair) and mostly in gorillas of

Kyaguliro group and in black backs and silver backs. The average percentage of abnormal observations was highest with black-backs at 1.14% (29/2551) and lowest with infants (0.03%, n= 3672). In the different gorilla groups, the percentage of abnormal observations was higher in Kyaguliro group at 0.94% (40/4258) and lowest in Rushegura group (0.12%, n= 3280). Abnormal observations were significantly more in black backs and less in Infants. In all groups, there was less than 1 abnormal observation per 100 individual gorilla observations.

Overall 1/3 of all gorillas had something identified as abnormal during the one year study period. Kyaguliro group had the highest period prevalence of abnormal observations at 66.2% while Rushegura group at 7.7% had the lowest. In the different age / sex classes, black-backs had the highest prevalence and Infants had the lowest at 87.7% and 6.2% respectively.

All the tourist groups (Habinyanja, Mubale, Nkuringo, and Rushegura) at times move out of the park. Kyaguliro group never moved out of the park. Nkuringo group significantly spent more time out of the park than any other group. Habinyanja group had the biggest home range of 32.52 km^2 followed by Nkuringo group (25.95 km^2) at 95%UD. Mubale group had the smallest home range of 8.05 km^2. There was no relationship between group size and home range.

Gorilla health monitoring using symptoms is a good basis for disease outbreak monitoring because it gives an insight of every day happenings in gorilla groups and this study being the first of its kind covering all the habituated groups of BINP is important in providing the baseline monitoring parameters for the these habituated mountain gorilla groups.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

The world's population of Mountain Gorillas (*Gorilla beringei beringei*) is estimated to be approximately 720 individuals in two isolated habitats, Bwindi Impenetrable National Park and the Virunga Massif (McNeilage *et al.*, 2001; Gray *et al*., 2005; McNeilage *et al.*, 2007). Both of these protected areas are surrounded by some of the densest and fastest growing human populations on earth. The human communities around the mountain gorilla parks have a density of 420 - 820 people per square kilometre (Ministry of Finance, Planning and Economic Development, Uganda 1997) and have a population growth rate of approximately 3.7% (Cranifield *et al.,* 2002). These populations are accompanied by intensive agricultural practices. There is a very active ecotourism industry as well as the presence of behavioural research programs in both areas, which bring conservation personnel as well as tourists into regular close contact with habituated groups of gorillas within the park. During times of political unrest, people often utilise the park for travel routes, and make refugee camps at the border of the parks causing additional environmental pressure. Due to low numbers and genetic studies showing that each animal's genetic input into the population's genome is important, the mountain gorillas are managed on an individual level as well as a population basis with respect to veterinary care (Cranifield *et al.,* 2002).

1.2 Background

In Uganda, the tourism sector is the number one foreign exchange earner and for Uganda Wildlife Authority (UWA), gorilla tracking generates over 50% of all internally generated revenue with one habituated gorilla group generating approximately over one million dollars a year (Personal communication).

In numerous conferences concerning great ape health, it has been hypothesised that transmission of human diseases to apes is a (if not the) major threat to species survival. A consistent recommendation of these conferences is a need for a systematic approach to health data collection, yielding solid evidence on which to base intervention strategies for reducing disease transmission (MGVP 2006).

Baseline data on health of free-ranging wildlife is essential to evaluate impacts of habitat transformation and wildlife translocation, habituation, rehabilitation, and re-introduction programs. Health information on many species, especially great apes, is extremely limited (Kilbourn, *et.al*., 2003).

People living around protected areas are among the poorest in their countries and have very little access to primary health care. As a result, preventable diseases such as, tuberculosis, scabies, diarrhoeal diseases and intestinal parasites persist in these local communities (GAHMU, 2004). Because great apes and humans have closely related genetic make up (Hastings *et al*., 1991), mountain gorillas are threatened not only by poaching and habitat loss, but also by human diseases (Butynski and Kalina, 1998).

At the Population and Habitat Viability Assessment sponsored by the Conservation Breeding Specialist Group (CBSG) of the World Conservation Union (IUCN), gorilla experts recognized, from experiences with great apes in captivity and limited data from wild populations, that the potential introduction of diseases from the human population to the mountain gorilla is one of the greatest threats to their long-term viability (PHVA, 1997).

The Mountain Gorilla Veterinary Project (MGVP) and the Uganda Wildlife Authority (UWA) veterinarians monitor the health of the Ugandan gorilla populations by observation, non-invasive biological sampling, and post mortem examination. Interventions occur only in life threatening situations (particularly human induced[1]) and are utilized to obtain clinical data on the compromised individual and, where applicable, baseline data on the group and population level (Cranifield *et al.,* 2002).

1.3 Study area description

[1] Human induced situations are those that are known to be arising out of human actions such as trapping

Bwindi Impenetrable National Park is a montane forest ranging between 1160m and 2607m altitudes in South-western Uganda (0^0 53’ – 1^0 08N’; 29^0 35’ – 29^0 50’E). The park was initially gazetted as a forest reserve in 1932 (Howard, 1991) and it became a National park in 1991 (Butynski and Kalina, 1993) to protect its population of gorillas and its plant and bird biodiversity (Hamilton, 1976; Keith, 1980; and Davenport, et al. 1996). The area of the park is approximately 331 square kilometres characterised by numerous steep-sided hills and narrow valleys (McNeilage, et al. 2001).

1.4 Statement of the problem

Access to mountain gorilla biological samples other than urine and faeces is currently limited to the available archived materials (hair, blood, urine, faeces, formalized tissue etc.) and collection during interventions for life threatening problems. Important baseline data is therefore collected infrequently and on an opportunistic basis. This is compounded by the limited availability of local laboratories, and validated diagnostic tests for gorillas. These hamper the ability to obtain a definitive diagnosis in the presence of clinical signs.

The mountain gorilla conservation organisations and agencies have attempted to establish a disease contingency plan but lack of knowledge on how diseases express themselves in this species is a major missing brick to the puzzle. Disease severity indices combined with rule out lists were formulated and used to generate risk categories, each with assigned actions to be taken in order to limit the spread of disease until a definitive diagnosis is reached. It was thus decided that the contingency plan will be triggered by types and extent of the clinical picture and yet the baseline data of the latter is non existent. Therefore, this research was aimed at identification and assessment of clinical parameters. In 2004, a pilot clinical sign based study was done by Rwego in Nkuringo group in Bwindi Impenetrable National Park to understand the baseline prevalence of clinical signs using a clinical sign assessment form (Rwego 2004). However, the use of this form requires a clinician. Given that it is practically impossible to have clinicians visit all groups every day, a basic health monitoring form was developed for symptomatic observation and reporting of gorilla health by the rangers who visit all groups every day hence the need for the current study to evaluate the ranger based symptomatic observations as a health monitoring tool for the mountain gorillas.

1.5 Objectives of the study

1) To establish the baseline general monitoring parameters of habituated mountain gorillas of BINP specifically:
   i) To determine the average number and composition of mountain gorilla trackers and the percentage tourist occupancy of gorilla groups in BINP.
   ii) To determine the observability[2] of the gorillas in the different gorilla groups and age / sex classes.
   iii) To determine the observability of the different bodily systems[3] of observed gorillas in the different gorilla groups and age / sex classes.

2) To establish the number, proportion and type of abnormal body system observations among the habituated mountain gorillas of BINP specifically:
   i) To determine the proportion of abnormal system observations in the different gorilla groups and age / sex classes.
   ii) To determine the period prevalence of an abnormal system for habituated mountain gorillas of BINP.
   iii) To determine the common observed clinical signs among the habituated gorillas of BINP and their spatial location.

3) To determine the spatial location, ranging pattern, and kennel home ranges of the habituated gorillas of BINP

1.6 Significance of the study

Knowing how diseases invade and spread in family groups and populations is part of a modern approach for wildlife veterinarians and conservation management. Therefore a

[2] Observability is the percentage of gorillas observed out of the potential number of gorillas that could have been observed if every individual were observed.

[3] Bodily system: To ease observations and recording of symptoms, the gorilla is observed according to different systems like general body, integumentary, respiratory, discharges, and defecation.

precise knowledge of which factors are associated with observed clinical signs would help to know which factors are influencing the epidemiology of disease most intensively and which age / sex class or groups are most vulnerable.

A database for storing information on mountain gorilla clinical signs has been developed thus, a system for long term health monitoring and effective response to abnormal situations like disease outbreaks in this highly endangered species was initiated. This information system also has the potential to be replicated in other protected areas and conservation centres for health monitoring of other species.

CHAPTER TWO

LITERATURE REVIEW

2.1 The mountain Gorilla

2.1.1 Gorilla taxonomy

Up until very recently a single species of gorilla, *Gorilla gorilla,* with three subspecies, was recognized. This comprised two eastern subspecies, *Gorilla gorilla graueri* (eastern lowland gorilla) and *Gorilla gorilla beringei* (mountain gorilla) and one western subspecies, *Gorilla gorilla gorilla*. (UNEP-WCMC, 2003a)

However, recently western and eastern populations have been recognised as separate full species, *Gorilla gorilla* and *Gorilla beringei* respectively. (UNEP-WCMC, 2003a) The eastern and western populations are separated by approximately 1,000 km (Garner and Ryder, 1996). Western and eastern populations can be distinguished based on external features (Groves, 2002) and clear geographic and morphological distinctions can also be seen (Garner and Ryder, 1996). In the western group, the isolated Nigeria-Cameroon gorillas are now recognised as a subspecies, Cross River Gorilla *G. g. diehli*, and the Western Lowland Gorilla, *G. g. gorilla*, though there is much divergence even within this subgroup. The eastern group includes both the Eastern lowland *G. beringei graueri* and the two mountain populations of *G. b. beringei*.

Following the newer taxonomic classification, among the mountain gorillas, the Bwindi mountain gorilla may form a third subspecies, *Gorilla beringei bwindi* as suggested by Sarmiento *et al*. (1996) although the taxonomic status of the populations is as yet unclear (McNeilage *et al*., 2001). Sarmiento *et al*. (1996) list a number of morphological and ecological differences between the gorillas of Bwindi-Impenetrable Forest and the Virunga volcanoes, and insist that Bwindi gorillas do not belong to *G. b. beringei* and so should not be called mountain gorillas. Stanford (2001) contests this and suggests that the evidence showing the Bwindi and Virunga gorillas to be taxonomically distinct is not well supported. Garner and Ryder (1996) found that the populations of mountain gorilla in the Virunga

Volcanoes region and the Bwindi forest were indistinguishable using a particular mitochondrial DNA region.

2.1.2 Biological data

Much of the information collected on the mountain gorilla comes from research studies conducted on the Virunga population, particularly studies done at Karisoke Research Centre in Rwanda. Comparatively few studies have been conducted on the diet, ecology and demography of the mountain gorillas in Bwindi (McNeilage *et al*., 2001).

The mountain gorilla of the Virunga lives in groups that may range in size from two to 52 animals, and although group structure can vary, more than 60% of groups contain only one mature male or silverback (Harcourt *et al.,* 1981; Gray *et al*., 2005). Most mountain gorilla groups have one fully mature male (silverback), several reproducing females and juveniles of both sexes (Harcourt *et al.,* 1981) and complex group dynamics and interactions are exhibited (Sicotte, 1995; Watts, 1994; Yamagiwa, 1999; Robbins, 1996). However, all-male and multi-male groups also occur. Information from the study groups of the Karisoke Research Centre showed that females reached sexual maturity at 7 ½ years of age, although a two year period of adolescent sterility is experienced and that, although males in captivity can mature at 8 years of age, they generally do not breed in the wild until about 15 years of age as a result of competition they face from older dominant males (Harcourt *et al.*, 1981).

Upon reaching maturity, both the males and females leave the natal group. The females usually join another group or a lone young adult male, whereas the males remain solitary until they can attract females and establish their own groups (Masicot, 2003). After emigration, some males may spend a large proportion of their time in their natal group's home range (Harcourt *et al.,* 1981). It is unusual for adult males to migrate into other groups (Yamagiwa, 1987). Of the 15 changes in the size and composition of the two main study groups between 1972 and 1974 listed by Harcourt *et al*. (1981), 11 were due to migrations.

Mountain gorillas are folivores that specialise on plant parts, species and families (Watts, 1984). The leaves of *Galium ruwenzoriense, Arundinaria alpina, Rubus* species. and the stems of *Peucedanum linderi* have been shown to be the preferred species of the mountain gorilla (Plumptre, 1995) with particular preference for *A. alpina* (bamboo) shoots (Vedder, 1984). Animal matter (Watts, 1984), sediment (Mahaney *et al*., 1990) and excrement (Graczyk and Cranfield, 2003) have been observed to be eaten infrequently. Bwindi mountain gorillas consume more fruit than the Virunga gorillas (Sarmiento *et al*., 1996).

2.1.3 Distribution

There are two known populations of mountain gorilla, all of which occur in national parks (Appendix 1). One population occurs on the extinct volcanoes of the Virunga Massif along the borders of the Democratic Republic of the Congo (DRC), Rwanda (RW), and Uganda (UG) within the Virunga National Park of DRC, the Volcano National Park in Rwanda and to a lesser extent the Mgahinga National Park, Uganda, A separate population of mountain gorillas is found in the Bwindi-Impenetrable National Park in southwest Uganda, on the border of DRC (UNEP-WCMC and WWF, 2001).

Democratic Republic of the Congo: The mountain gorilla, *Gorilla beringei beringei* occurs in the Virunga National Park of DRC. The Virunga National Park is 790,000 hectares in size and is contiguous to Rwenzori Mountains National Park in Uganda and Volcanoes National Park in Rwanda, the latter of which is also home to mountain gorillas. It ranges in altitude from 798 m to 5,119 m. It is located in northeast DRC mostly in Kivu Province (95%) and also in Haut-Zaire (5%), on the border with Rwanda and Uganda (UNEP-WCMC, 2003b). A gorilla population on Mt. Kahuzi in the Democratic Republic of the Congo has been referred to as *G. b. beringei* by some authors, although it is generally agreed that it is actually a population of *Gorilla gorilla graueri* (Nowak, 1999).

Rwanda: The mountain gorilla, *G. b. beringei* occurs in the Volcano National Park, which is 12,500-13,000 hectares in size and is contiguous to Virunga National Park in DRC and Mgahinga Gorilla National Park in Uganda. It ranges in altitude from 2,400 m to 4,507 m

(UNEP-WCMC, 2003b). It is situated 15 km northwest of the town of Ruhengeri in the Virunga Massif on the Ugandan and DRC borders.

Uganda: The mountain gorilla, *G. b. beringei* occurs in the Mgahinga National Park, Uganda and Bwindi-Impenetrable National Park, Uganda. The Mgahinga National Park is 2,899 hectares in size and is found in the extreme southwest of Uganda on the borders with DRC and Rwanda and was established strictly for the protection of mountain gorillas. It ranges in altitude from 2,700 m to 4,127 m and consists of the partly forested slopes of three extinct volcanoes. The Bwindi-Impenetrable National Park is 32,092 hectares and ranges in altitude from 1,190 m to 2,607 m. It is located in the Kigezi highlands of southwest Uganda, on the edge of the western rift valley and borders DRC to the west (UNEP-WCMC, 2003b).

2.1.4 The mountain gorilla habitat

The habitat of *Gorilla beringei beringei* consists of subtropical/tropical Moist Forest (IUCN, 2002). Forest edges and regenerating or secondary forest are favoured gorilla habitat (IUCN, 1982). A number of vegetation zones have been identified in the mountain gorilla habitat of the central Virunga Volcano region, which mostly consists of *Hagenia-Hypericum* woodland with a relatively open canopy and extremely dense herbaceous under storey (Watts, 1997). Mountain gorillas range up to 3400 m in altitude with occasional forays even higher (IUCN, 1982). Bwindi gorillas tend to live in lower elevations, warmer temperatures and are more arboreal than Virunga gorillas (Sarmiento *et al*., 1996). The area of habitat occupied by the mountain gorilla in the Virunga is approximately 375 km^2 and the Bwindi gorillas occupy an area of approximately 215 km^2 (Butynski, 2001).

2.1.5 Population estimates and trends

Population counts and estimates of mountain gorillas are commonly carried out on the basis of nest or sleeping site counts (Inogwabini *et al.,* 2000). Adults and immature weaned animals build new nests to sleep in each night. The nests are counted and any dung adjacent to each nest examined gives a reliable indication of group size as well as age group of animal, particularly when the counts are repeated over 3 consecutive nights. The number of mountain gorillas declined throughout the 1970s and early 1980s, and some declines were seen into the 1990s (Binyeri *et al.,* 2002). IUCN (1982) described a decline in the mountain gorilla numbers in the Virunga, from 400-500 in the late 1950s, to 275 in 1973 to 250 by 1981, with most of the decline occurring in the DRC section. However, by the mid 1980s the mountain gorillas of the Virunga had started to gradually increase again. The 1989 count of mountain gorillas in the Volcano National Park, Virunga National Park and Mgahinga National Park was about 306 animals (Plumptre and Harris, 1995). Most recently a population estimate, based on repeated observations of 17 habituated groups and information on 15 unhabituated groups, has shown the population of the Virunga mountain gorilla to be between 359 and 395 (Kalpers *et al*., 2003).

In 1979, estimates showed that there were 95-130 mountain gorillas in the Bwindi Impenetrable Forest Reserve (IUCN, 1982). Harcourt *et al*. (1981) noted a total population size of 155 in Bwindi (where 33% of the population was counted). More recently McNeilage *et al*. (2001) estimated the population in Bwindi-Impenetrable National Park in 1997 to be 292 individuals and this population appeared to be stable. At least 300 individuals were reported in Bwindi Impenetrable Forest National Park (Uganda Wildlife Division, 2002).

The mountain gorilla appears to be gradually increasing in numbers. Based on recent estimates (Kalpers *et al*., 2003 and McNeilage *et al*., 2001), the total number of mountain gorillas may be between 651 and 687, or according to Plumptre *et al.* (2003) there are a total of approximately 650-700 mountain gorillas. The Virunga population of mountain gorilla has increased by 14% in the last 12 years. The Bwindi population is stable and may also be increasing (Uganda Wildlife Division, 2002; McNeilage *et al*., 2001).

Table 1: Comparison of population size and structure across censuses

Population parameter	Bwindi			Virunga	
	1997	2002	2006	1989	2003
Number of groups	28	27	30	32	32
Number of solitary males	7	10	11	6	11

Estimated population size	300	320	340	324	380
Mean group size	10.2	11.3	10.8	9.2	11.4
Range of group size	2-23	3-25	3-28	-	3-52
Proportion of immature individuals	37%	36%	36%	45.5%	41.0%
Proportion of multi-male groups	46%	44%	23%	28%	36%
Number of habituated groups	3	5	5	-	16
Individuals in habituated groups	52	72	76	-	269
Proportion of population habituated	17.3%	22.5%	22.4%	-	70.8%

Data courtesy of Institute of Tropic Forest Conservation (ITFC)

2.1.6 Conservation status

The IUCN Red List (IUCN 1982) classifies the mountain gorilla as *G. beringei beringei* and is classified as Endangered, on the basis that a reduction in population size had occurred over the last 10 years or three generations, and the reduction or its causes may not have ceased or may not be understood or may not be reversible. It was assessed in 2000, by T. Butynski and Members of the Primate Specialist Group. However, IUCN (2002) also assessed the two populations of mountain gorilla separately due to the taxonomic uncertainty that currently surrounds them. When considered separately (i.e. the Virunga and the Bwindi population as separate entities) each population is considered Critically Endangered (IUCN, 2002). Despite the low numbers of gorillas and the severe threats they face, overall population numbers would appear to be stable and possibly slowly increasing.

2.1.7 Actual and potential threats

The major threats to mountain gorillas are (1) habitat loss or modification (e.g. through infrastructure development, wood extraction, human settlement and agricultural crops (IUCN, 2002)) and forest encroachment (Muruthi *et al*., 2000), (2) hunting or poaching, (3) disease transmission from humans and (4) war or political unrest (Plumptre *et al*., 2003; Muruthi *et al*., 2000; IUCN, 2002), (5) other threats which include the risk of inbreeding (Muruthi *et al*., 2000) and ongoing disturbance from tourism (IUCN, 2002). The mountain gorilla populations are separated by densely populated land and intense human land use which are putting intense pressure on both populations (GROMS, 2002). Increasing human settlement contributes to virtually all the threats listed above such as demand for land to live on and to farm, and demand for fuel and food. Gorillas are critically endangered and are slow reproducing animals implying that low mortality rates can have devastating impacts.

Exploitation: In the Virunga and Volcano National Parks of DRC and Rwanda, infant gorillas may be captured for sale, and adult males killed so that their skulls can be sold as souvenirs to tourists. Adults may also be killed in order to gain access to the infants. An infant can reportedly fetch as much as £86,000 on the black market (Vesperini, 2002).

Habitat degradation/loss: The mountain gorilla lives in an area where there is a high human population size and growth rate. In Burundi, Rwanda and Uganda, including Bwindi Impenetrable Forest Reserve, fragments of forest form part of a landscape that supports one of the highest densities of rural human populations in Africa (Taylor *et al*., 1999). The main threat to gorillas in DRC is forest clearance and, although no land has been appropriated from the habitat of the Virunga gorillas, declines may be due to the presence of livestock in the Virunga (IUCN, 1982). Deforestation to supply refugees' demand for fuel wood has affected 105 km^2 of the park, of which 35 km^2 has been completely stripped (UNEP-WCMC, 2003b).

Impact of Conflict: The early 1990s saw the outbreak of fighting in Rwanda, which by April 1994 had expanded into DRC and resulted in a stream of refugees pouring into gorilla habitat. Indeed, approximately 50% of Rwanda's civilian populations were displaced during this conflict, of which 860,000 refugees were concentrated in the vicinity of Virunga National Park (Dudley *et al*., 2002).

The streams of refugees that were displaced during these conflicts led to uncontrolled firewood harvesting, and increased poaching in the Virunga National Park and the death of more than four silverback mountain gorillas (UNEP-WCMC and WWF, 2001) and disruption of natural animal migration patterns (UNEPWCMC, 2003b). Three of the four refugee camps in North Kivu were located in or near to the park buffer zone, and it is estimated that at least 500,000 hectares of the park have been affected by wood harvesting or poaching (UNEP-WCMC, 2003b). After the refugees left in 1996, conflict in the DRC led to looting and destruction of infrastructure in the Park, as well as the possible death of 15 Virunga mountain gorillas (UNEP-WCMC and WWF, 2001). Kalpers *et al*. (2003) reported that between 12 and 17 gorillas are known to have died between 1992 and 2000 in the Virunga volcanoes region as a direct result of military activity. Concern for the protection and management of the site, especially with regards to recurring encroachments, deforestation, poaching, population growth, and the refugee related problems that have arisen due to civil unrest in Rwanda, led to the site being placed on the World Heritage in Danger List in 1994 (UNESCO, 1994). The situation around Virunga is unstable, militia groups may still be active in the region, aerial census of the area has not been possible since 1995 and there are frequent reports of poaching, deforestation and illegal gold mining in the park (UNEP-WCMC, 2003b). Much of the Virunga has clearly been severely affected by conflict.

Other threats

A potential threat to gorillas is exposure to human diseases (Graczyk *et al*., 2001a and Graczyk *et al*., 2001b) particularly for habituated gorillas that come into contact with humans, in areas of gorilla tourism (UNEP-WCMC and WWF, 2001). Gorilla tourism exposes gorillas to humans and hence to any diseases that humans may be carrying, some of which the gorillas may never have been exposed to before.

An outbreak of scabies in a habituated group of gorillas in Bwindi Impenetrable National Park in 1996 led to the death of an infant male, and the treatment by injections of three others (Kalema-Zikusoka *et al*., 2002). A subsequent outbreak of scabies occurred in Bwindi National Park in 2000, although no mortality was recorded (Mudakikwa, 2001). The source of this disease is unknown, but there would appear to be a high prevalence of the disease in the people living around the Park (Kalema-Zikusoka *et al*., 2002). Williamson (1999) reported that in Volcano National Park the most serious threat to the gorillas may be the acquisition of human parasites and disease and recently a number of gorillas in this Park died of an unknown illness (UNEP-WCMC, 2003c). An outbreak of a respiratory disease, with the possibility of measles as the primary infection, in the Parc National des

Volcano in Rwanda claimed six gorilla lives, and 27 other gorillas were successfully treated (Wallis and Lee, 1999). However, there are few data on the impacts of disease, particularly outside the Virunga (Plumptre *et al.*, 2003).

Accidental entrapment in snares used to trap other wild animals is also a threat to the mountains gorillas. Plumptre *et al*. (1997) stated that the setting of snares for ungulates in the Volcano National Park, Rwanda is one of the greatest threats to *Gorilla beringei beringei*. However, Williamson (1999) reported that at least 99% of the three research groups in the Volcano National Park, Rwanda were in good physical shape.

The isolation and low numbers of mountain gorilla populations have given rise to concerns about inbreeding (Garner and Ryder, 1996). The mitochondrial DNA of the Virunga and the Bwindi mountain gorillas exhibited low variability further strengthening this concern, although more extensive sampling is required (Garner and Ryder, 1996).

2.1.8 Legislation

Internationally the mountain gorilla, *Gorilla beringei beringei*, is listed in Appendix I of the Convention on Migratory Species (CMS). The gorilla, *Gorilla gorilla*, was listed in CITES Appendix I in 1975, and all Range States (countries in which gorillas are naturally found) are Parties. In 1969, the gorilla was listed in Class A of the African Convention on the Conservation of Nature and Natural Resources. Both Virunga National Park and Bwindi-Impenetrable National Park are World Heritage Areas. The Democratic Republic of the Congo has ratified and Uganda and Rwanda have accepted the Convention Concerning the Protection of the World Cultural and Natural Heritage (the World Heritage Convention).

Nationally all mountain gorilla populations occur within national parks, they and their habitat afford some degree of protection. However, political and institutional instability as well as illegal hunting and poaching may undermine such protection. National laws in all range states exist for the control of hunting and capture of the gorillas, although wide enforcement of the legislation is difficult due to lack of funds and inaccessibility (Nellemann and Newton, 2002).

2.1.9 Mountain gorilla age / sex classes

Mountain gorilla age and sex classes can be categorised as silver-back, black-back, adult-female, sub-adult / juvenile, and infant. Directly, the relative sizes and physical features (silvery back hair for silver-backs) are used to distinguish between the age / sex categories. Indirectly, the measurement of dung sizes at nest sites along with presence / absence of silver hairs can be used to establish the age and sex composition of a gorilla group. Dung size categories used are: adult male, >7.2cm (with silver hairs); adult female or black back male, 5.5-7.2 cm; juvenile / sub adult < 5.5 cm (sleeping in own nest); infant, generally < 4cm (sleeping in mother's nest) (McNeilage, *et al.*, 2006).

2.2 Disease risks to the gorillas

To facilitate ecotourism and research, free-ranging mountain gorillas of Uganda have been habituated to humans (Graczyk *et al*., 2002). Disease transmission from humans to gorillas is a significant threat to their survival due to their close genetic relation to humans and susceptibility to human diseases (Woodford *et al.*, 2002). With such a small, isolated population, any infectious disease could devastate the population. During the 1990s and early 2000s there were extended periods of human presence in the park, as refugees and armed groups took harbour in the forest environment. These groups of people were living without proper sanitation (latrines), increasing the risk of disease transmission to the gorilla population. The human presence may also cause direct disturbance to gorilla ranging patterns as gorillas avoid areas of human activity. Gorillas are known to have died as a direct result of the insecurity in the park (Kalpers *et al*., 2003).

The daily visits of tourists to the gorillas also pose a risk in terms of behavioural disturbance and disease transmission. Whilst the tourism programmes have been very successful in creating economic and political incentives for gorilla conservation they may also be having a long-term negative impact on the gorillas. Threats associated with the habituation of wild gorillas include higher exposure to human-borne diseases, an increase in the ease of approaching and subsequently harming gorillas, and overall disturbance of behaviour patterns (Butynski & Kalina, 1998). If poorly controlled, tourism can lead to increased stress in the animals, which can increase susceptibility to disease (Woodford et al., 2002). Recent research has shown that the presence of tourists is associated with reduced time spent feeding, and that gorillas regularly move off or react in other ways in response to visitors and guides (Muyambi, 2004).

2.3 Wildlife health monitoring and surveillance

Baseline data on health of free-ranging wildlife is essential to evaluate impacts of habitat transformation and wildlife translocation, rehabilitation, and reintroduction programs. Health information on many species, especially great apes, is extremely limited (Kilbourn *et al*., 2003).

It is now recognized that those countries which conduct disease surveillance of their wild animal populations are more likely to detect the presence of infectious and zoonotic diseases and to swiftly adopt counter measures. The surveillance and monitoring of disease outbreaks in wildlife populations are particularly relevant now days due to rapid human and animal translocation, when the contact between wild and domestic animals is close and the threat of a bio-terrorist attack is very real (Morner, *et.al*., 2002).

A major advantage of an efficient disease-monitoring programme for wildlife is the early detection of new and 'emerging' diseases, some of which may have serious zoonotic and economic implications. Wildlife disease monitoring programmes that are integrated within national animal health surveillance infrastructures should have the capacity to respond promptly to the detection of unusual wildlife mortality and to institute epizootiological research into new and emerging wildlife diseases (Morner, *et.al*. 2002).

2.4 Recorded causes of death in Mountain gorillas

Post-mortem examination is important as it helps define causes of morbidity and mortality as well as providing insight into the most important health threats and high-risk categories within the populations. Ideally, thorough gross and histopathology examinations would be conducted on all dead gorillas. In reality, work is limited by the ability to recover dead gorillas, the field conditions under which gross post mortem exams are often conducted, and the quality of tissues available for histopathology exam and ancillary testing. Causes of death for 100 gorillas were analyzed by the MGVP. Causes of death by age and sex are presented in Table 2. The leading cause of death for all age classes is trauma. For infants, the primary type of trauma is infanticide (13/15), while for juveniles (7/9) and adults (15/16) direct or indirect poaching is the main type of trauma. Respiratory disease is the second most common cause of death and, in this dataset, affects all age classes equally. More than 25% of mountain gorilla deaths are related to infectious disease (Nutter *et.al.,* 2005).

Table 2: Causes of death by age class

Cause	Infant	Juvenile	Adult	% of total
Trauma	15	9	16	40
Respiratory	8	6	10	24
Undetermined	9	1	7	17
Multifactorial	1	0	4	5
Gastrointestinal	1	1	2	4
Metabolic	1	1	1	3
Cardiac	0	0	3	3
Infectious - other	0	0	1	1
Developmental	1	0	0	1
Neurologic	1	0	0	1
Parasitic	1	0	0	1
	38	18	44	100

Data source: Nutter *et.al.,* 2005

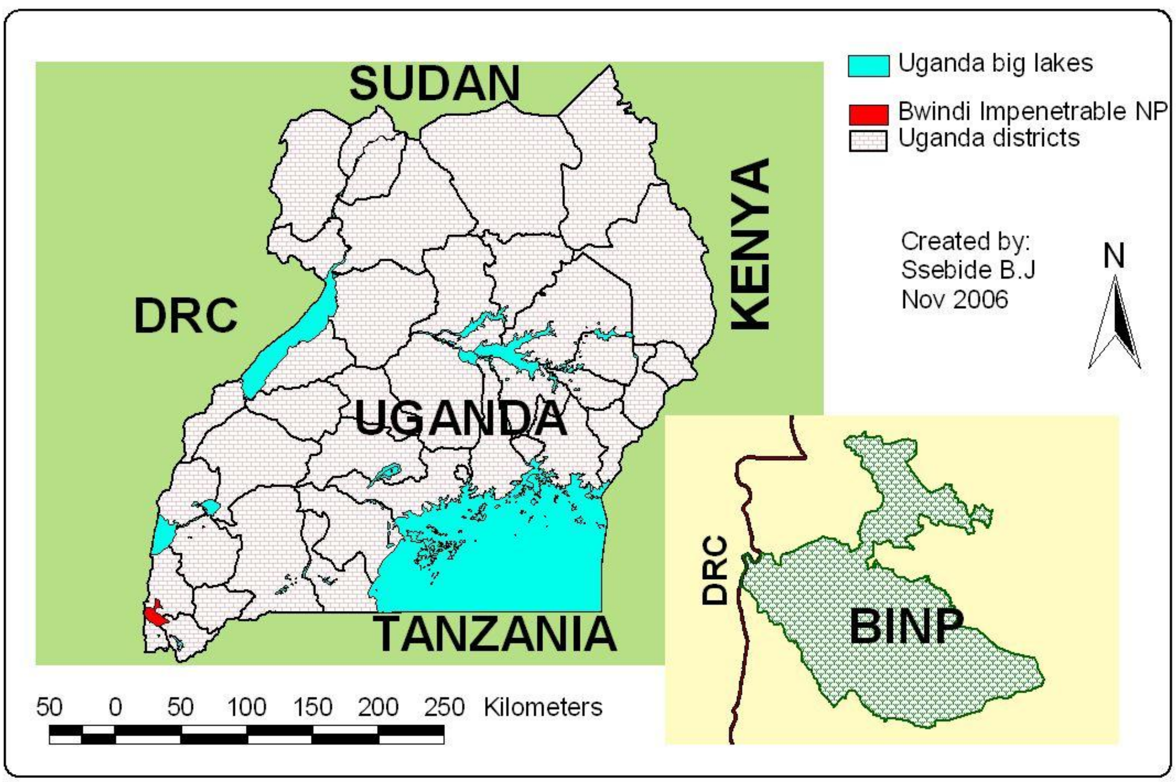
CHAPTER THREE

MATERIALS AND METHODS

3.1 Research design

The research was carried out in Bwindi Impenetrable National Park (BINP) in south western Uganda and touches the border with the Democratic Republic of Congo (Figure 1). This study focused on the habituated mountain gorillas. Five groups were observed: four tourist groups and one research group. The groups were observed for a period of 12 months from September 2005 to August 2006. The observations were made as part of the UWA Ranger Based Data Collection (RBDC) program and a data collection dictionary (Appendix 2) was used in order to standardise the recording of observations.

Figure 1: Map of Uganda showing the location of the study area



Map data courtesy of Uganda Wildlife Authority

3.2 Data collection

On a daily basis, Bwindi Mgahinga Conservation Area (BMCA) rangers collected behaviour and ecological data on mountain gorillas in data sheets as part of the ranger based monitoring programme. Some health data was also being collected on these data sheets (Appendix 3). The design of that system made it difficult to collect systematic health data and to carry out timely analysis and interpretation of the data.

The MGVP developed software for mountain gorilla health monitoring called IMPACT (Internet-supported Management Programme to Assist Conservation Technologies). The ranger-based ecological monitoring system was synchronized with IMPACT so that field staff could use just one data sheet (Appendix 4), and or a handheld computer Personal Digital Assistant (PDA) to record behavioural, ecological, and health data, so that data collection would not be duplicated. As a pilot project, all BMCA ranger guides and trackers were trained to collect basic health data on mountain gorilla health and a clinical reporting system was set up using data sheets and or handheld computers (PDAs). The rangers received training in observing, identification and recording of mountain gorilla health data (Figure 2) on data sheets and or PDAs. A system was also set up for transferring the data collected on datasheets and or PDAs to a computer for analysis.

Figure 2: Nasal discharge (left) and eye infection (right) as examples of abnormal observations in gorillas

3.3 Data analysis

In order to perform detailed analysis of the general monitoring parameters and detection rates of abnormal systems and of various clinical signs in different groups and age /sex categories, data was entered in Microsoft excel and was analysed using the Statistical Package for Social Science (SPSS) software. This was aimed at doing analyses specific to gorilla groups, and sex / age categories. A X^2 test was used to test the significance of the difference between observation parameters in the different gorilla groups and age / sex classes and the tests was interpreted as: $X^2 > 3.84$ means significant difference; $X^2 > 6.63$ means very significant difference; and $X^2 > 10.83$ means highly very significant difference (Lang and Secic, 1997)

Basic mapping of the gorilla locations and the kennel home range analysis of the gorilla groups under observation was done using Arc View software (ESRI Inc., version 3.2a, Redlands, California USA).

The kernel home range estimator was used for estimation of the gorilla home range. It produced a utilization distribution (UD) that can be viewed as an area probability that a certain % of the locations of the animal were within that range. A 50% UD for example says that 50% of the time, the groups were in that area. Kernel estimators tend to stabilize in size after about 20-30 observations, after which the estimators much less influenced by sample size. The h-factor is a smoothing factor for the resulting kernel grids that are developed. This means that the kernel estimator converts the world to a series of rows and columns that create a grid. These grid cells are then populated with a probability value that the group would occur in that cell. The smaller the h-factor, the smoother the final home range estimation, but the longer the analysis program takes to run. Arc View uses an h-factor that is a fractional component of the total home range size and that is why they vary from group to group.

3.4 Ranger reliability testing

Because the data collection system required the use of the Rangers as part of the Ranger Based Monitoring system, parallel data was collected where by for the days I visited the gorilla groups, in addition to the data collected by the rangers, I also independently collected observational data on those days. This parallel data was analysed using SPSS as a way to test how effective, efficient, and reliable is the data collected by the rangers.

There was no difference in observability (X2 = 2.84) in the different gorilla groups and in the different age / sex classes between my observations and those of the rangers (**Tables 3 and 4**).

Table 3: Comparison of gorilla observability by gorilla groups between my observations and those of the rangers

	Habinyanja	Mubale	Nkuringo	Rushegura	Total
Personal observation	64.9% (314/484)	91.2% (156/171)	65.8% (402/611)	89.2% (232/260)	72.3% (1104/1526)
Trackers observations	71.9% (348/484)	97.1% (166/171)	66.3% (405/611)	86.9% (226/260)	75.0% (1145/1526)

Table 4: Comparison of gorilla observability by age / sex classes between my observations and those of the rangers

	Adult females	Black backs	Infant	Juveniles	Silver backs	Total
Personal observation	76.6% (344/449)	54.4% (123/226)	72.0% (249/346)	70.3% (249/354)	92.1% (139/151)	72.3% (1104/1526)
Trackers observations	79.7% (358/449)	57.5% (130/226)	73.4% (254/346)	74.6% (264/354)	92.1% (139/151)	75.0% (1145/1526)

CHAPTER FOUR

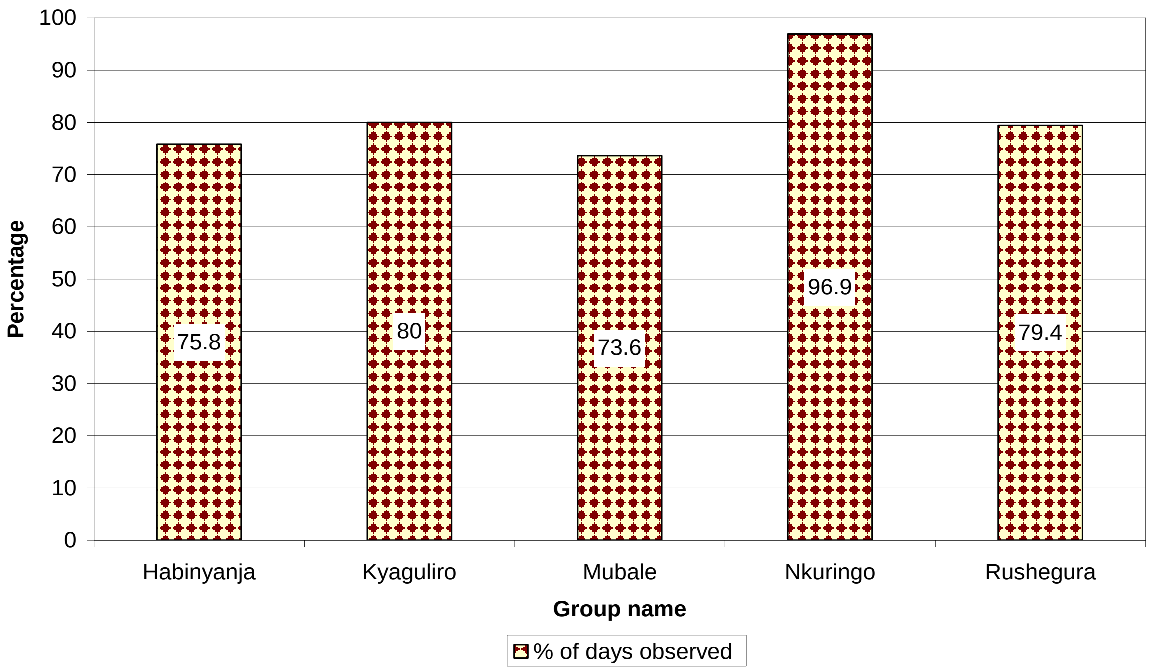
RESULTS

4.1 General observations

4.1.1 Gorilla groups observation days

Overall, there were 1825 (5 groups x 365 days) potential gorilla group observation days for all the five groups of which 1482 (81.2%) gorilla group observation days were recorded. The percentage of total observation days per group were as shown in Figure 3.

Figure 3: Percentage of the total observation days per gorilla group



4.1.2 Number and composition of tracking teams

Habinyanja group had the greatest number of people tracking it per day and Kyaguliro group had the least. The average number and composition of the people tracking the gorillas per day is shown in Table 5.

Table 5: Average number and composition of the gorilla tracking teams

	Habinyanja	Kyaguliro	Mubale	Nkuringo	Rushegura
Average number of trackers	15.9 ±0.29	4.0±0.00	16.1±0.30	11.3±0.32	15.7±0.28
Average number of tourists	6.4±0.13	0±0.00	6.3±0.14	4.5±0.17	6.4±0.13
% tourists	40	0	39.1	39.8	40.5
% non-tourist trackers	60	100	60.9	60.2	59.5

The team tracking gorillas usually includes the trackers and guides, the tourists, the porters, the military escorts, and sometimes other people like veterinarians, wardens, and researchers. The tourists groups i.e. Habinyanja, Mubale, Nkuringo, and Rushegura had many people tracking them per day compared with the research group i.e. Kyaguliro group where there is no tourism activity allowed. Tourists generally form 40% of the total number of people tracking the tourism gorilla groups per day.

4.1.3 Average number of tourists

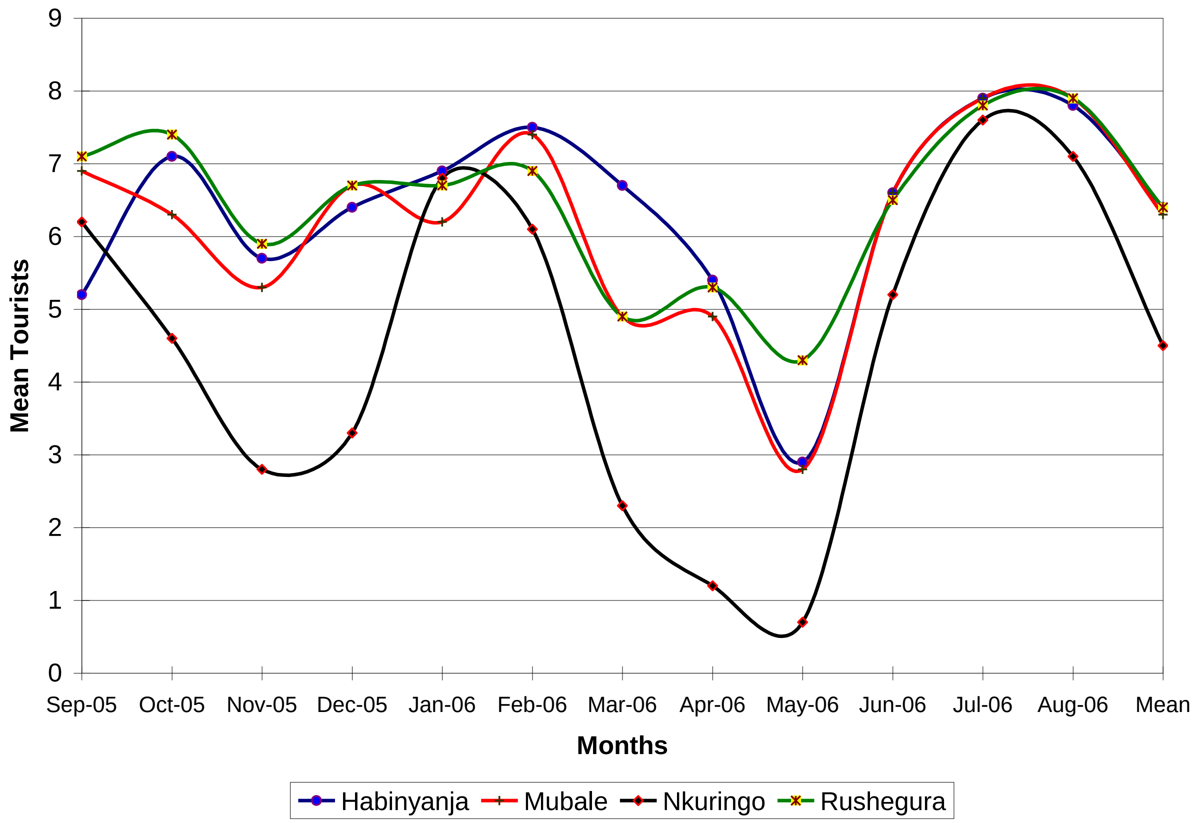
The maximum number of tourists allowed per group per day is eight for the tourist groups and none for the research group. Table 6 shows the average number of tourists per group per day over the one year study period and the average tourists' occupancy of the gorilla groups. As noted in the table, the average number of tourists observed per day was slightly higher for Habinyanja, Mubale, and Rushegura groups than for Nkuringo group. Kyaguliro is a research group hence no tourists were recorded there.

Table 6: Average number of tourists per day

	Habinyanja	Kyaguliro	Mubale	Nkuringo	Rushegura
Mean number of tourists	6.4±0.13	0±0.00	6.3±0.14	4.5±0.17	6.4±0.13
% occupancy	80	0	78.7	56.2	80

Fluctuations in the number of visitors were observed in November, April, and May registering fewer visitors than other months (Figure 4). Throughout the study period, Nkuringo group substantially had fewer visitors than other tourists groups. There was however no substantial difference in the number of visitors between Habinyanja, Mubale, and Rushegura groups.

Figure 4: Average number of tourists per month



4.1.4 Demographic changes during the study period

The composition of the study gorilla groups varied from time to time during the study period due to births, deaths, and immigrations as shown in Table 7. There were no demographic changes in Habinyanja and Rushegura groups. In Kyaguliro group two (2) babies were born during the study period. In Mubale group, a baby was born and died a month later while in Nkuringo group; a black back emigrated out of the group during the study period. There were no new immigrants into any of the study groups. Given that gorillas have an approximately 4-year inter-birth interval (Watts, 1991) population growth will be inherently slow even at its maximum potential rate. This is probably why an overall increase in the study population of only 1 individual over the one year study period was observed.

Table 7: Gorilla demographic changes over the study period

Gorilla Group	Death	Birth	Emigration	Immigration
Habinyanja	0	0	0	0
Kyaguliro	0	2	0	0
Mubale	1	1	0	0
Nkuringo	0	0	1	0
Rushegura	0	0	0	0
Total	1	3	1	0

4.1.5 Composition of study population

The average group composition is given by the total number of potential individual observations[4] divided by the number of the observation days. On average, 76.6 individual gorillas in 5 groups were studied (Table 8).

[4] For individuals born or that die during the study, they are counted as contributing to the potential individual observations just the number they could have contributed, once they were born (or dead).

Table 8: Average composition[5] of study population

	Adult-females	Black-backs	Infants	Juveniles	Silver-backs	Total	% total
Habinyanja	7	2	5	6	2	22	28.7
Kyaguliro	6	4	2.1	2	1	15.1	19.7
Mubale	3	0	1.1	3	1	8.1	10.6
Nkuringo	4	5.4	4	3	2	18.4	24.1
Rushegura	5	0	4	3	1	13	16.9
Total	25	11.4	16.2	17	7	76.6	100
% total	32.7	14.9	21.1	22.2	9.1	100	-

There were fluctuations in gorilla numbers during the study period. At the beginning of the study, there were a total of 76 individuals in the five study groups while they were 77 by the end of the study period.

Habinyanja group had the biggest number of individuals and Mubale group had the least comprising 28.7% and 10.6% of all gorillas respectively. Bwindi gorilla groups range in size from 3-25 and only 11% of all groups in Bwindi could be considered large, containing 20 or more gorillas (McNeilage, *et.al*., 2006). Adult females formed the majority of the study population, 33%, while silver-backs formed 9% of the study population. The juveniles, infants, and black-backs formed 22%, 21%, and 15% respectively.

[5] Table 8 shows average composition and the decimal points are due to fluctuations in group composition due to births, deaths, and migrations as shown in table 7.

4.2 Individual gorilla observations

4.2.1 Potential individual gorilla observations

The total number of potential individual gorilla observations in a particular group is the sum of all individual gorillas in that group times the number of days that group was observed. Individuals that are born or die during the study, their potential individual observations are only those days from when they are born or before they die respectively. For the study period, a total of 22939 individual gorilla observations would have been made if every individual gorilla were seen each observation day for all the study groups as shown in Table 9.

Table 9: Number of potential individual gorilla observations

	Adult-females	Black-backs	Infants	Juveniles	Silver-backs	Total	% of total
Habinyanja	1930	552	1382	1656	553	6073	26.5
Kyaguliro	1752	1168	611	584	292	4407	19.2
Mubale	801	0	313	801	269	2184	9.5
Nkuringo	1412	1915	1412	1059	707	6505	28.4
Rushegura	1450	0	1160	870	290	3770	16.4
Total	7345	3635	4878	4970	2111	22939	100
% of total	32.0	15.8	21.3	21.7	9.2	100	-

4.2.2 Number of individual gorilla observations made

Table 10 shows the number of individual gorilla observations made stratified by gorilla group and age / sex classes. On every gorilla group observation day, individual gorillas that are observed or seen are indicated so. It is rare that all individuals in a particular group are seen during gorilla observations particularly in the big groups. During the study period, a total of 18018 individual gorilla observations were made. There were no black-backs in Mubale and Rushaga groups.

Table 10: Number of individual gorilla observations during the study period

	Adult-females	Black-backs	Infants	Juveniles	Silver-backs	Total	% of total
Habinyanja	1372	439	737	1005	533	4086	22.7
Kyaguliro	1682	1133	596	561	286	4258	23.6
Mubale	759	0	255	767	269	2050	11.4
Nkuringo	942	979	1092	727	604	4344	24.1
Rushegura	1275	0	992	724	289	3280	18.2
Total	6030	2551	3672	3784	1981	18018	100
% of total	33.5	14.2	20.4	21.0	11.0	100	

4.2.3 Percentage of gorillas seen during the study period / observability

A total of 18018 individual gorilla observations were made out of the potential 22939 resulting into an overall observability of individual gorillas of 78.5% (18018/22939) as shown in Table 11 and in Figures 5 and 6. There were no black-backs in Mubale and Rushegura groups hence the 0%.

Table 11: Percentage of gorilla seen during the study period / observability

	Adult-females	**Black-backs**	**Infants**	**Juveniles**	**Silver-backs**	**Mean %**
Habinyanja	71.1	79.5	53.3	60.7	96.4	67.3
Kyaguliro	96.0	97.0	97.5	96.1	97.9	96.6
Mubale	94.8	NA	81.5	95.8	100	93.9
Nkuringo	66.7	51.1	77.3	68.6	85.4	66.8
Rushegura	87.9	NA	85.5	83.2	99.7	87.0
Mean %	82.1	70.2	75.3	76.1	93.8	78.5

Figure 5: Gorilla observability by gorilla groups

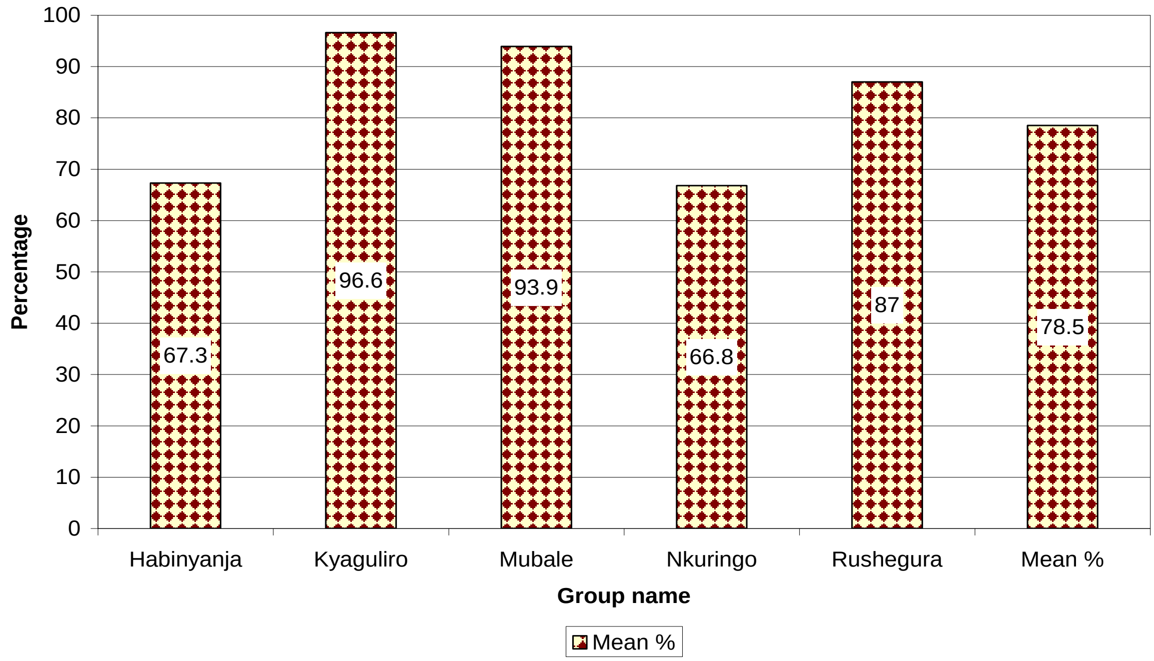
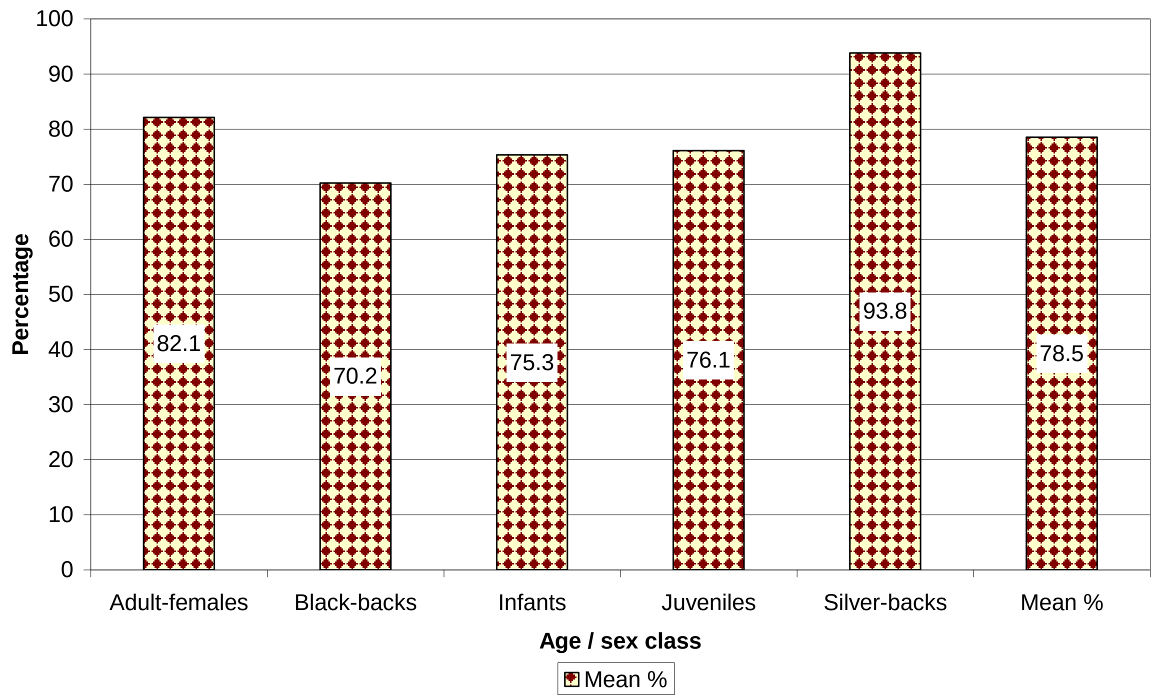


Figure 6: Gorilla observability by age / sex classes



4.3 Bodily system observations

The individual gorillas were divided up into bodily systems to ease observation and recording of symptoms as defined in Appendix 2. Discharge head is the observation of the whole head area for any discharges. It involves observation of the nose, the eyes, ears, mouth and the other parts of the head. Discharge other is the observation of the whole body of the gorilla including the genital area for any discharge.

4.3.1 Individual gorilla bodily system observations by gorilla groups

Tables 12, 13 and Figure 7 show the average percentage of times each system was observed for all individual gorilla observations.

Table 12: The % of times each system was observed given the gorilla was seen by gorilla group

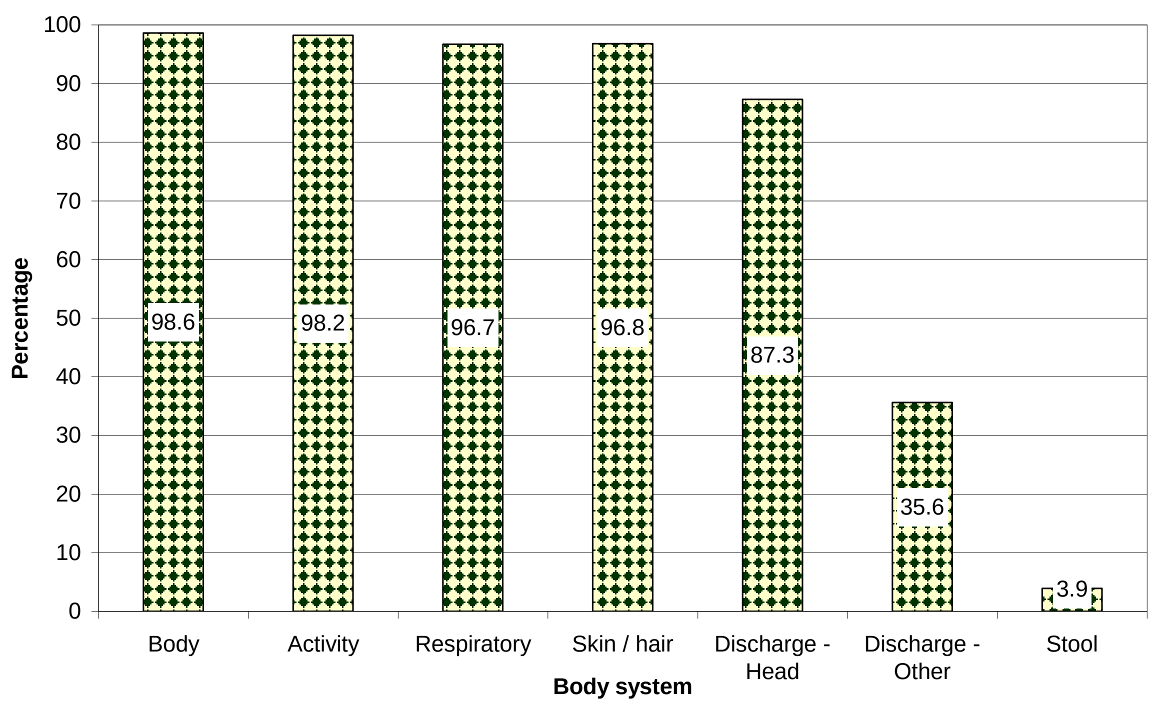
	Habinyanja	Kyaguliro	Mubale	Nkuringo	Rushegura	Overall
Body	97.2	99.4	97.9	99.0	99.4	98.6
Activity	97.0	99.8	96.0	97.9	99.1	98.2
Respiratory	95.3	99.1	95.0	95.0	98.6	96.7
Skin / hair	95.4	99.4	95.2	94.7	98.8	96.8
Discharge head	93.4	76.4	94.6	81.4	97.0	87.3
Discharge other	31.4	62.4	45.0	15.4	26.9	35.6
Defecation	0.5	13.4	0.7	1.7	0.7	3.9

4.3.2 Individual gorilla bodily system observations by age / sex class

Table 13: The % of times each system was observed given the gorilla was seen by age / sex class

	Adult - females	Black - backs	Infants	Juveniles	Silver - backs	Overall
Body	98.9	98.7	98.2	98.4	98.9	98.6
Activity	98.5	98.4	97.7	97.7	98.4	98.2
Respiratory	97.3	96.8	95.9	96.7	95.9	96.7
Skin / hair	97.4	96.9	96.1	96.8	95.8	96.8
Discharge head	88.6	81.1	86.5	90.1	86.5	87.3
Discharge other	39.5	39.8	28.5	34.6	33.4	35.6
Defecation	4.6	6.9	1.9	2.4	4.2	3.9

Figure 7: The % of times each system was observed given the gorilla was seen



4.4 Abnormal system observations

4.4.1 Percentage of abnormal bodily system observations by gorilla group

Table 14 shows the percentage of times a particular body system was abnormal given it was observed stratified by gorilla group. No abnormal observations were made on the body system and no abnormal discharge-other were observed. The abnormal stool was observed only in Habinyanja group. In Mubale group, abnormalities were observed only on the skin / hair system.

Table 14: The % of times each system was abnormal given the system was observed by gorilla group

	Habinyanja	Kyaguliro	Mubale	Nkuringo	Rushegura	Overall %
Body	0	0	0	0	0	0
Activity	0	0.05	0	0.28	0	0.08
Respiratory	0.03	0	0	0.05	0.06	0.03
Skin / hair	0.38	0.76	0.15	0.27	0.06	0.36
Discharge head	0.03	0.25	0	0	0	0.06
Discharge other	0	0	0	0	0	0
Defecation	5	0	0	0	0	0.14

4.4.2 Percentage of abnormal bodily system observations by age / sex class

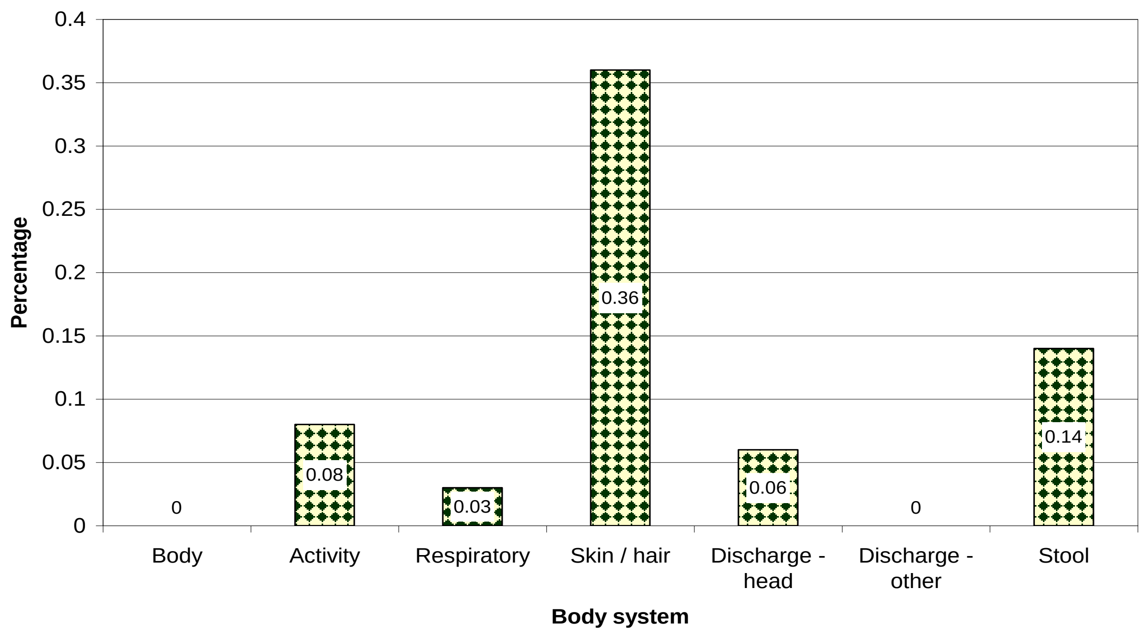
Table 15 shows the percentage of times a particular body system was abnormal given it was observed stratified by age / sex class. The only abnormality observed among infants was on the respiratory system. In other age / sex classes, abnormalities were observed in more than 1 body system. Abnormal observation of stool was only recorded in silver backs. Diarrhoea of non pathological origin is some times observed in silver backs as and immediate reaction to a stressful condition.

Table 15: The % of times each system was abnormal given the system was observed by age class

	Adult - females	Black - backs	Infants	Juveniles	Silver - backs	Overall
Body	0	0	0	0	0	0
Activity	0	0.52	0	0.03	0	0.08
Respiratory	0.03	0	0.03	0.05	0	0.03
Skin / hair	0.44	0.65	0	0.25	0.63	0.36
Discharge head	0.15	0	0	0	0.06	0.06
Discharge other	0	0	0	0	0	0
Defecation	0	0	0	0	1.19	0.14

Figure 8 shows the percentage of times a particular body system was abnormal given it was observed. The skin and hair body system had most of the abnormal observations.

Figure 8: The % of times each system was abnormal given the system was observed



4.4.3 Number of abnormal observations during the study period

During the study period, 86[6] abnormal observations were made in the different gorilla groups and age / sex classes as shown in Table 16. Forty point seven percent (n=86) of the abnormal observations were made among adult females. Among gorilla groups, most abnormal observations were made in Kyaguliro group (46.5%). In Mubale and Rushegura groups, abnormal observations were made only among adult females.

Table 16: Number of abnormal observations

	Habinyanja	Kyaguliro	Mubale	Nkuringo	Rushegura	Total	% of total
Adult-females	3	25	3	0	4	35	40.7
Black-backs	1	12	-	16	-	29	33.7
Infants	1	0	0	0	0	1	1.2
Juveniles	1	2	0	6	0	9	10.5
Silver-backs	10	1	0	1	0	12	14.0
Total	16	40	3	23	4	86	100
% of total	18.6	46.5	3.5	26.7	4.7	100	-

[6] This includes gorillas observed more than one time with the same condition for example a condition that is prolonged in one individual and so recorded as observed many times

4.4.4 Percentage of abnormal observations

There were 0.48 abnormal observations per 100 individual gorilla observations as shown in Table 17.

Table 17: Percentage of abnormal observations

	Habinyanja	Kyaguliro	Mubale	Nkuringo	Rushegura	Average / observation
Adult-females	0.21	1.48	0.39	0	0.31	0.58
Black-backs	0.22	1.05	0	1.63	0	1.14
Infants	0.13	0	0	0	0	0.03
Juveniles	0.09	0.35	0	0.82	0	0.24
Silver-backs	1.87	0.34	0	0.16	0	0.60
Average / observation	0.39	0.94	0.15	0.53	0.12	0.48

4.4.5 Period prevalence of abnormal observations

Table 18 shows the percentage of gorillas that had an abnormal system (any system) one or more times / at least once during the one year study period (period prevalence) sub-analyzed by gorilla group and age / sex class.

Table 18: Percentage of gorillas that had an abnormal system (any system) at least once during the study period (period prevalence)

	Adult-females	**Black-backs**	**Infants**	**Juveniles**	**Silver-backs**	**Total**
Habinyanja	42.8	50.0	20.0	16.6	100	36.4
Kyaguliro	66.6	100	0	50.0	100	66.2
Mubale	66.6	0	0	0	0	24.7
Nkuringo	0	92.6	0	33.3	50.0	38.0
Rushegura	20.0	0	0	0	0	7.7
Total	40.0	87.7	6.2	17.6	57.1	36.5

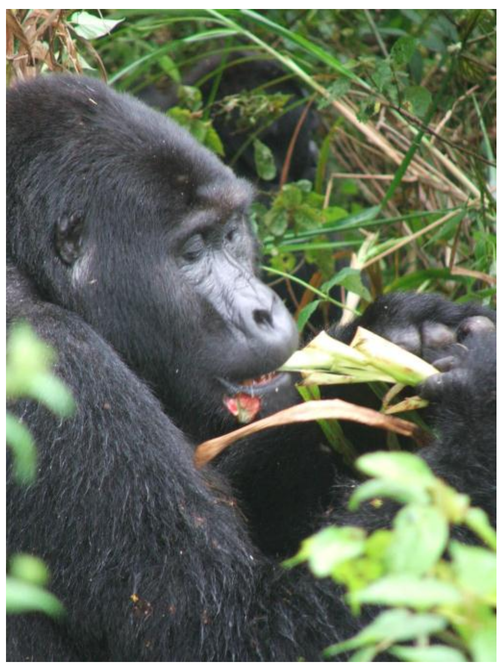
4.4.6 Observed symptoms

Abnormal system observations were classified into different symptoms as shown in Table 19. Frequency indicates the number of times the abnormality was observed / recorded.

Table 19: Type of symptoms observed

Type of observation	Frequency	Percent
Diarrhoea (watery stool)	1	1.16
Cough	4	4.65
Nasal discharge	8	9.30
Broken limb, limping	14	16.28
Wounds, cuts	59	68.60

Figure 9: A limping black-back gorilla due to a sprained limb (left) and a gorilla with a fresh mouth wound / cut (right)



4.5 Ranging pattern analysis

4.5.1 Gorilla groups observation locations

The location of the gorilla group during observations was classified into three categories as inside the park, outside the park, and park boundary area meaning that the group moved in and out or the reverse during the observation. Table 20 shows the percentage of times a group was found in a particular location in relation to the park boundary.

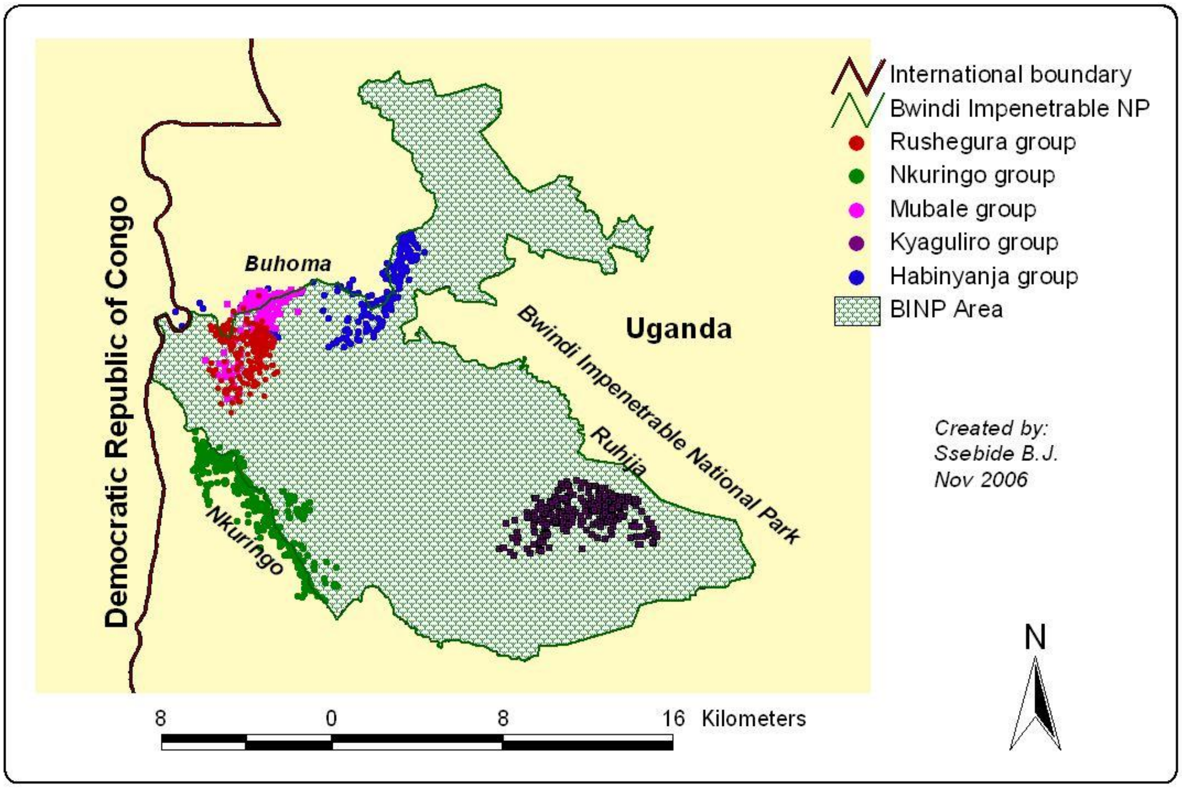
Table 20: Percentage location of groups during observations

	Habinyanja	Kyaguliro	Mubale	Nkuringo	Rushegura
Boundary area (%)	7.9	0	4.5	30.8	6.9
Inside park (%)	86.6	100	81.8	48.3	91.0
Outside park (%)	5.4	0	13.3	20.9	2.1

All the tourist groups (Habinyanja, Mubale, Nkuringo, and Rushegura) at times move out of the park. Kyaguliro group never moved out of the park. Nkuringo group spends more time out of the park than any other group. They were viewed inside the park only 48.3% of the times.

The Nkuringo group ranges in the Southern part of the park and Kyaguliro group in the Eastern part. There was no interaction between these two groups and any other habituated group of BINP.

Figure 10: Location of groups during observations



Map data courtesy of Uganda Wildlife Authority

4.5.2 Gorilla home range analysis

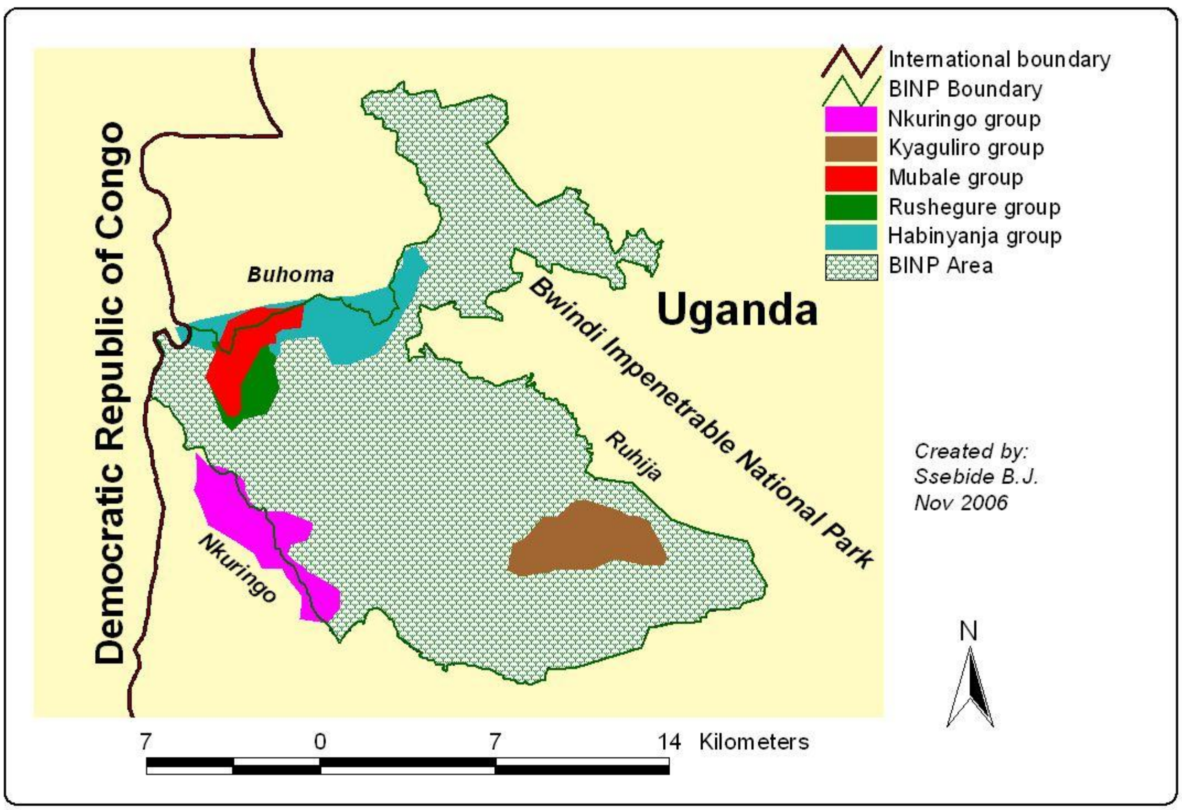
The home range sizes for the different groups studied are summarized in Table 21.

Table 21: Gorilla annual home ranges

Group name	Kennel home range analysis		
	H-value	Home range 95% UD	Home range 50% UD
Habinyanja	613.92	32.52 km^2	5.06 km^2
Kyaguliro	342.24	19.87 km^2	4.61 km^2
Mubale	273.77	6.16 km^2	1.08 km^2
Nkuringo	482.09	25.95 km^2	5.15 km^2
Rushegura	241.59	8.05 km^2	0.48 km^2

Habinyanja group had the biggest home range of 32.52 km^2 followed by Nkuringo group (25.95 km^2) at 95%UD. Mubale group had the smallest home range of 8.05 km^2. There was no relationship between group size and home range as can be seen with Kyaguliro group which is medium in size like Rushegura group but with a home range that is more than twice that of Rushegura group. The size of the group's home range could be related to food availability and inter-group aggressions in that some groups may be forced to move further distances in avoidance of other nearby groups.

Figure 17: Gorilla annual home ranges



Map data courtesy of Uganda Wildlife Authority

CHAPTER FIVE

DISCUSSION

Health monitoring by symptoms using the daily clinical observation form is important for monitoring disease outbreaks because it gives an insight into whatever is happening in the gorilla groups every day. However, there is need for regular and consistent supervision of data collection, entry and analysis in order to provide timely and meaningful feedback for management purposes. There was evidence of data loss during this study. Gorilla tracking is a daily exercise and data collection for monitoring purposes is part of the normal reporting procedures for habituated gorilla groups in UWA. Yet only 81.2% of the potential daily gorilla observation data was provided and analyzed. Important monitoring data, if lost or not collected, creates a potentially dangerous information gap.

On average, at least 15 people enter the park per day to track Habinyanja, Mubale and Rushegura groups while an average of 11 people enter to track Nkuringo group. Although not all the trackers get into close contact with the gorillas, all trackers have a direct effect ecologically on the park and the fact that they travel through the gorilla home range, they can potentially pose a health risk to the gorilla population. Therefore programs and activities aimed at reducing health risks posed by people on gorillas should target all the trackers and not only the tourists and guides who get into close contact with the gorillas and make only about 40% of the total trackers.

Tourism occupancy of tourist gorilla groups has a direct implication on the amount of revenue generated by UWA. The results of this study show that there is still a gap to be exploited by UWA in order to maximise the much needed revenue arising out of gorilla tourism by implementing interventions such as increased marketing aimed at increasing the occupancy rate. The observed low seasons could also be the rationale for season based pricing of tracking fees and encouraging complementary visitors. Local communities could be given a chance to track for free during the low seasons and this chance utilised for conservation education and awareness campaigns.

Comparing observability of the gorillas by gorilla groups, Kyaguliro group individuals were seen most with 96.6% and Nkuringo group individuals were seen least with 66.8% (Figure 5). Statistically, there was no significant difference in gorilla observability between Habinyanja and Nkuringo groups (X^2 = 0.35, Pearson's Chi-square). There was however very highly significant differences in observability between all the other groups (X^2 > 10.83, Pearson's Chi-square). The difference in the percentages of observability could be due to the fact that Kyaguliro group, a research group, is observed for 4 hours compared to the other groups were only 1 hour is allowed for viewing. Secondly the size of the group (Figure 12) could also account for the difference in that although Mubale group is viewed for only 1 hour, it's small in size thereby making many individual observations much easier compared to the other groups. Age groups are not being seen with equal "probability" across gorilla groups but overall, Kyaguliro and Mubale group members in the different age sex classes are seen more compared to the other groups for the same reasons above i.e. duration of observation and group size. Figure 12 illustrates the difference in size hence observability between a group of less than 10 individuals versus a group of more than 20 individuals.

Figure 12: Small (left) and large (right) gorilla groups under observation

Regarding observability by age / sex class, silverbacks were seen most at 93.8% while black-backs were least seen at 70.2% (Figure 6). The difference in observability between the different age / sex classes was very highly significant ($p<0.01$, Pearson's Chi-square). There was however no significant difference in observability between infants and juveniles ($X^2 = 0.99$, Pearson's Chi-square). Silverbacks are easier to see compared to the other sex / age classes because of their position in the group. They usually defend the group, they are easily identifiable and hence easier to observe. They are generally few in number, usually one or two, so it is easier to see all of them. In addition, silver backs are targeted first by the trackers to ensure safe visits so they have to always be watched. It is important to note however that some groups have more than one silverback in which case sometimes only the dominant one is observed hence the observed observability of less than 100%.

Only 87.3% of seen individuals were observed enough to make a ruling on discharge head. Discharge other was a difficult observation to make and only 35.6% of seen individuals were observed to this extent. It requires observation of the individual from many angles which is rare given the gorilla is either resting or moving. It is rare to find gorillas in a very open place hence the vegetation type also make this observation a difficult one. The most difficult observations to make were faecal observations. Gorillas tend to defecate in the nests in the morning and therefore rare to see them defecating. Only 699 (3.9%) times they were seen defecating out of 18018 individual observations made. Between the different groups, however, the average percentage of times each system was observed given the gorilla was seen are comparable apart from Kyaguliro and Mubale group. The average percentage of times stool was observed given the gorilla was seen was highest in Kyaguliro group (13.4%) more than ten times compared to all other groups. This is attributable to the fact that Kyaguliro group is observed for 4 hours compared to the other groups in which observations are allowed for only 1 hour. Observation of defecation is therefore not a dependable way of detection of sickness in individual mountain gorillas through routine monitoring of one hour's duration, during tourist tracking. The same conclusion also applies for "discharge other" because often this bodily part isn't seen.

The percentage of times a particular system was abnormal given the system was observed were all below 1% or zero. This being the first study of this kind covering all the habituated gorilla groups in Bwindi, it therefore sets the expected annual baseline for the different systems at below 1% under normal (non outbreak) conditions.

There was no significant difference in the average percentage of abnormal observations between adult females and silver backs ($X^2 = 0.01$, Pearson's Chi-square, $p>0.05$). Abnormal observations were made significantly more in black backs and less in infants. This however should not be interpreted as more gorillas but potentially longer duration of a similar condition observed in the same individual as was the case with a sprained limb in a black back in Nkuringo group. This data should therefore not be quoted as "prevalence" or % of gorillas but rather it's % of observations. The monitoring parameter here is the encounter rate of abnormal observations. Statistically, the difference in the percentage of abnormal observations between Kyaguliro and Mubale, and between Kyaguliro and Rushegura was very highly significant ($p<0.01$, Pearson's Chi-square) but the differences between Habinyanja and Mubale, Habinyanja and Nkuringo, and Mubale and Rushegura were not significant ($p>0.05$, Pearson's Chi-square). In all groups, there was less than 1 abnormal observation per 100 individual gorilla observations.

Given that the trackers and guides had training in identification and recording of symptoms, from the study it can be concluded that the animals are in good health. The alternative could be that one can't tell that the gorillas are "sick or diseased" from just clinical signs in that the conditions may be sub clinical. This is however unlikely because gorillas are tracked on a daily basis and if any had a sub clinical illness, it would probably show up in the subsequent days. For gorillas that had one or more abnormal systems, they were continuously observed the following days until the abnormality resolved. It is important that gorillas with a suspect abnormality be followed up during subsequent days until the suspect condition has been resolution, as a standard protocol. One option would be to program IMPACT so that when there is an abnormality recorded, the system asks the user the next time he / she logs on if that individual is ok or not now in order to prompt the user to ensure the gorilla is seen to record resolution of the problem.

Overall 1/3 of all gorillas had something identified as abnormal during the one year study period. In health terms, this is a big proportion however the proportions differ significantly when looking at different gorilla groups and different age / sex classes. Comparing the period prevalence of an abnormal bodily system among different gorilla groups, Kyaguliro had the highest prevalence of 66.2% (10/15.1) and the lowest was observed in Rushegura group at 7.7% (1/13). The difference in the percentages between Kyaguliro and Rushegura was highly significant (X^2 = 10.04, Pearson's Chi-square) and the differences between any other groups were not significant (X^2 < 3.84, Pearson's Chi-square). More than 50% of individuals in Kyaguliro group had something identifiable as abnormal during the study period. This could be due to the prolonged observation duration (4 hours) and better identification of the individuals. By age / sex classes, black-backs had the highest prevalence of 87.7% (10/11.4) and the lowest was observed in infants at 6.2% (1/16.2). Almost all black-backs during the study period had something that was assessed as abnormal for which the skin/hair contributed most. All these abnormalities resolved themselves without intervention and were ultimately not problematic.

Out of the 86 abnormal observations made, 59 (68.60%) were wounds and cuts on the integumentary system (skin and hair) and mostly in gorillas of Kyaguliro group and in black backs and silver backs (Tables 12 and 13). Wounds and cuts are usually associated with inter group and intra group aggressions. Given that black backs and silver backs are the defendants of the groups and are the ones involved in hierarchical aggression fights, they are the most affected with wound and cuts (Figure 16) than any other age class. In terms of infectious and non infectious disease signs, only cough, nasal discharge and diarrhoea (watery stool) could be suspected as infectious. These were observed very few times and they all resolved spontaneously thereby posing no big threat to the rest of the individuals or population.

Habinyanja, Mubale, and Rushegura groups range in the North eastern part of the park and the three groups interact in their home range. They all move out of the park sometimes. The three groups are usually seen feeding on Eucalyptus trees and banana plantations whenever seen out of the park. Their movements out of the park are related to food attractions in those areas where they move to. The home range of Nkuringo group is along the Kashasha river valley in Nkuringo area. The river forms the boundary of the park but in this area, community land adjacent to the park measuring approximately 4.4km^2 was bought off by UWA for purposes of creating a buffer zone and the regenerating forest on the opposite side of the park is not any different from the park itself in terms of vegetation. It could be the reason why gorillas are many times observed in this area since it has the food that gorillas eat. The home ranges of Habinyanja, Mubale, and Rushegura group intersect meaning that the three groups at times use the same area of the park. Although no relationship was observed in the frequency of common clinical observations in groups that share home ranges compared to those which do not interact at all, it is important to note that the risk of spread of infectious diseases is high if an outbreak occurs in one of those groups with a common home range.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The majority of people entering the park to track gorillas are not tourists. The average daily trackers of gorillas are 16 people for each of the three tourists groups of Buhoma i.e. Habinyanja, Mubale and Rushegura groups and 11 people for Nkuringo group (for which tourists generally make 40%). Gorilla tracking rules and guidelines intended to minimise the risk of disease transmission to gorillas should therefore also target and be emphasized to other trackers other than tourists only.

The average tourists' occupancy for Habinyanja, Mubale and Rushegura groups is 80% and 56% for Nkuringo group. There is therefore still room for increasing visitor numbers and hence tourism revenue out of gorilla tracking.

At least 3 in 4 individual gorillas are seen during gorilla observations. Observability is however higher where there is more observation time and where the group size is small. Silverbacks are also easier to see than other age / sex classes. Health problems are therefore easier to be detected in these categories gorillas.

Given the gorilla was seen, over 95% of times, its body, activity, respiratory, and integumentary (skin / hair) systems were also observed making these the best systems to use in health monitoring of gorillas using clinical signs. Stool and discharge other are not recommended as systems for routine monitoring of health since these are not often observed

Based on clinical sign observations, habituated mountain gorillas of Bwindi appear generally in good health. Given a particular body system was observed, the percentage of times that system was observed as abnormal was very low (below 0.5%). There were only 48 abnormal observations per 10,000 individual gorilla observations (0.48%). This study however showed a significant period prevalence of abnormal observations in individual gorillas. One in three (1/3) gorillas had an abnormal system (any system) at least once during the study period.

The most common clinical signs in BINP mountain gorillas are skin wounds and cuts and this constitutes over 60% of all observed clinical signs.

Apart from Kyaguliro group, all other habituated mountain gorilla groups of BINP move out of the park at sometime with Nkuringo group spending more time outside the park than any other group.

Three of the five habituated groups in Bwindi namely Habinyanja, Mubale, and Rushegura have an interacting home range. The groups' annual home range sizes vary. Habinyanja group has the biggest home range while Mubale group has the smallest.

6.2 Recommendations

In designing and management of programs aimed at reducing the potential transmission of diseases between humans and gorillas, all categories of people who get into close contact with the gorillas should be considered. A gorilla tracking team usually consists of tourists, trackers and guides, porters, military escorts, and others like veterinarians and researchers of whom tourists generally only form 40%. This study highlights the importance of Employee Health Program given that the larger percentage of people who track gorillas is not tourists. However the tourists are a sizeable percentage also so it's important that the rules regarding health risks to gorillas by tourists be enforced.

The average tourists' occupancy of BINP tourist gorilla groups is below 80%. Therefore there is still room for increased marketing and promotion in UWA in order to maximize the economic benefits of mountain gorilla eco-tourism. Alternatively, the space could be utilised for conservation education for local people.

The individual gorilla observability in the tourist groups was not satisfactory. An important recommendation arising out of this is for the stakeholders to conduct more training of trackers and guides in order to enhance gorilla identification by the trackers and guides who are the primary source of information regarding gorilla health. Although most of the observed abnormalities were not as problematic in that they resolved without intervention, most lasted a short time and were not infectious, it is important that all abnormalities are identified and recorded in case more serious potential triggers of outbreaks show up.

It was noted during this study that all habituated gorilla groups apart from Kyaguliro group move out of the park. This creates increased contact between gorillas, humans and domestic animals hence an increased potential for a zoonotic disease outbreak. There is therefore need for intensified community sensitization programs on health issues. Problem animal control strategies like creation of buffer zones are also essential. In addition monitoring and surveillance of diseases in humans and domestic animals is also necessary in order to prevent potential disease transmission between domestic animals, humans, and wildlife.

This study being the first of its kind covering all the habituated groups of BINP is important in providing the baseline monitoring parameters for the habituated mountain gorillas, essential for future evaluation of the impacts of habitat transformation, habituation, and eco-tourism programs on these wildlife populations.

CHAPTER SEVEN

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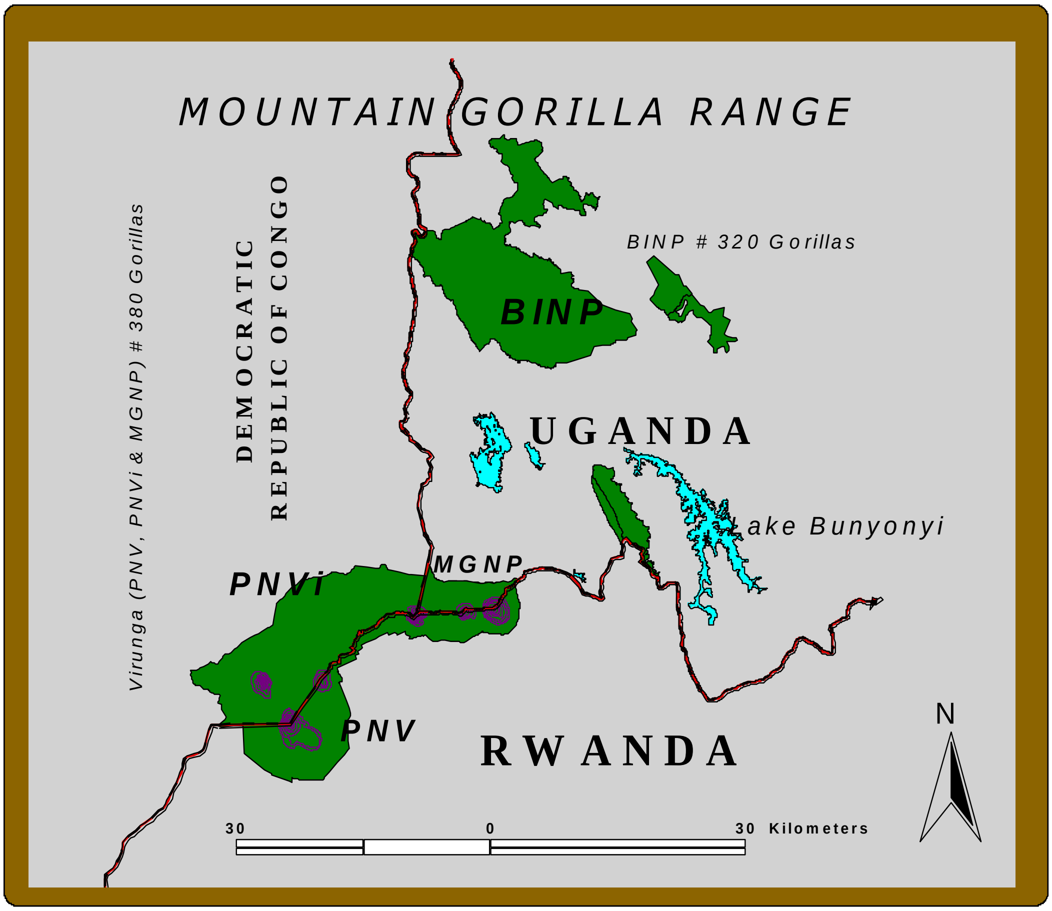
APPENDICES

Appendix 1: Mountain gorilla ranges



Map data courtesy of Uganda Wildlife Authority

Mountain gorillas (*Gorilla beringei beringei*) are found in Eastern Central Africa in two distinct populations one in the Virunga Massif shared between DRC, Rwanda, and Uganda; and the other population in BINP in Uganda.

Appendix 2: Dictionary for health data collection

Variable	Definition	
Date	Date of observation in day/month/year format	
Start time	Time you start observing the gorillas	
End time	Time you complete the day's observation	
Team leader	The person leading the tracking team usually a guide	
Other staff	The rest of the staff on the team usually trackers, and military escorts	
Nest location	Topographic name and geographic coordinates of place where nests are found	
Observation location	Topographic name and geographic coordinates of place where observations are made	
People present	SWIFT	Soldiers that are assigned by the army to escort tracking team
	Trackers / guides	Park employees assigned to track the gorillas
	Tourists	Persons who have come to track the gorillas
	Porters	Local people assigned to carry visitors luggage
	Others	Any other category of people e.g. researchers, vets, wardens
Vegetation type	The predominant type of vegetation in which observations are made	
Type of activity	The predominant type of activity gorillas are doing during the observation	
Food items	The unusual type of food gorillas are seen eating e.g. cultivated food crops	
Gorilla	The individual gorilla identity (name) for identified and named gorillas	
System	The general body system categories	
Comments	General remarks that the trackers may have noticed on a particular gorilla	
General comments	Any remarks for the day that the data recorder may want management to know	

Systems	Parameter	Signs	Definition of sign
Body condition: The physical state of a gorilla.	**Weight:** Body composition in terms of muscle mass & body fat.	Normal	Unable to see ribs outline
		Thin	Able to see ribs outline and notable muscle atrophy
		Very thin	Ribs obviously pronounced, facial muscles atrophy, sunken eyes, and body wt loss.
	Abdomen:	Normal	Convex appearance
		Flat	Abdomen & rib cage form a continuous line
		Sunken	Concave appearance & sunken
	General attitude: Manner of acting. Covers lethargy, listlessness and neurological signs	Normal	Age & context specific appropriate behaviours
		Mildly abnormal	Not behaving like the rest of the members at a particular time or in a particular context.
		Severely abnormal	Severely inappropriate behaviours in the context of its environment.
Activity: Quality of being active. This is also judged in the context of the time of the day, the environment and the rest of the group.	**Movement:** Act of passing whole body from one place to another.	Normal	Normal movement of entire body
		Lameness	Abnormal movement of one or more limbs leading to individual limping
		Lame	Lame and unable to keep up with the group.
	Manipulation: Any manual operation with limbs e.g. eating	Normal	Normal movement of all limbs during the daily activities of a gorilla
		Abnormal	Unable to perform normal movements of any part of one or more limbs.
	Appetite: A longing to satisfy hunger by taking food, chewing & swallowing	Normal	Taking in expected quantities of food, chewing 7 swallowing it without difficulty
		Little appetite	Taking in less than expected quantities of food.
		Severely abnormal	Not eating any thing at all when other group members are.

Respiratory: Relating to the respiratory system. The coughing pattern is interpreted in the context of the whole group.	**Breathing rate:** Frequency or number of breaths per minute	Normal	When animal appears comfortable without visible movement of nostrils and chest.
		Fast	When breathing is observed and higher than 20 breaths per minute.
		Slow	When breathing is observed and less than 15 breathes per minute.
	Breathing difficulty:	None	No breathing difficulty shown at all
		Laboured	Visible respiratory effort with or without respiratory noise.
	Coughing quality:	Normal	
		Dry	Harsh, grating, short sound, no mucus
		Productive	Moist cough
	Coughing pattern: The sequence of coughing.	Normal	Doesn't interrupt the activities of the individual
		Continuous	More than once in five minutes
		Periodic	Intermittent interruption of the activities of the individual due to coughing.
	Sneezing:	None	One episode of sneezing per observation
		Continuous	More than one episode of sneezing within 5 minutes.
		Periodic	Episodes of sneezing less than five minutes between then.
Skin and hair: Includes in addition to the epidermis and dermis all the derivatives of the epidermis i.e. hair, nails, sebaceous glands and mammary glands.	**Skin / hair:** The external covering of the individual and may have hair or not.	Normal	Skin and hair are as expected for the species and part of the body
		Blisters	Collection(s) of fluid under the epidermis or within the epidermis
		Scaly	Flaky whitish looking pieces of epidermis sloughing off the body
		Loss of hair	Reduced density of hair
		Other problems	Rashes, redness, ulcers, erosions, pustules, nodules, scars, extra.
	Wound: An injury to any part of the body caused by trauma	None	
		Cut	Superficial and limited to the skin surface
		Gash	More than the skin up to the muscles
		Severe gash	More skin and muscle affected affecting function of the body part affected
	Scratching: To rub to alleviate itching using nails or other objects	Normal	None or infrequent
		Periodic	Scratches now and then.
		Continuous	Scratching occurring more than once in every five minutes or continuously.
	Swelling: Abnormal enlargement of a body part or area	None	No swelling on the body
		One	
		Many	More than 1 swelling observed
	Swelling size:	Small	< 2.5 cm in diameter
		Large	> 2.5 cm in diameter
Discharge: Emitted or	Eyes / Ears Nose / Mouth	Clear	Colourless secretions
		Bloody	Secretion with a tinge of blood or real blood

evacuated as an excretion or a secretion	Vagina / penis / Anus Wound	Other colour	Whitish / yellow / green / cloudy
		Dried	Free from moisture
Stool: Faeces	**Defecation:** Discharge of excrement from the anus	Normal	Controlled elimination of faeces without straining
		Straining	Excessive effort in excreting faeces from the anus
	Stool consistence: The degree of texture or viscosity of the faeces	Dried	Harder than normal
		Normal	Faeces with expected consistency with discrete lobes
		Soft	No longer retains its normal shape but has a pudding consistency
		Watery	Stool that no longer retains any shape and consistency
	Stool colour: Colour of the faeces	Brown	Brown coloured faeces
		Black	Dark coloured stool
		Bloody red	Reddish tint indicating blood from the lower GIT
		Other	Other colour e.g. white, yellow, green
Other signs: Behaviours or signs other than the above	Fleeing	Observation of gorillas running away from the trackers	
	Fighting	Observation of gorillas engaged in a fight	
	Mating	Observation of gorillas mating	
	Charging	Observation of gorillas charging at the trackers	

Adapted from Rwego 2004

Appendix 3: Former gorilla data sheet

Gorilla Data Sheet (one data sheet per observation) - **BINP**

Date:	**Start time:**	**End time:**	**Name of Place:**		Gorillas: *Wild* ☐	*Habituated* ☐
Location: 35M			**UTM**			
Type of observation: *Seen* ☐ *Trail* ☐ *Nests* ☐			**For trail or nests:** *how many days old?*			
How many nests?:		**Vegetation type:** habitat where the observations were made				
			Bamboo	*Closed forest*	*Open forest*	*Outside Park*
Type of activity *(in general)*						Other
Eating	*Playing*	*Moving*	*Rest period*	*Between Group Interaction*		*Charging*
Composition of group *(animals visually observed)*						
	Silverback	Blackback	Adult females	Subadults	Juveniles	Infants
Number						
Habituated Groups: *List of animals observed present*				**Which group?**		
Gorillas not seen?:						

Food items (tick only the food items listed below, *unless you observe any other exceptional food item)*

Bamboo	☐	Fruits	☐	Dung	☐
Dirt	☐	Dead wood	☐	Drinking water	☐
Ants	☐	Mushrooms	☐	Any food eaten outside the forest	☐

Details if needed (type of fruit, etc.):

Health status of gorillas (Summary - details on back):

Are there any sick gorillas	YES ☐	NO ☐	*Details (name etc):*
Are there any wounded gorillas	YES ☐	NO ☐	

Have you informed headquarters/wardens of the wound or illness? YES ☐ NO ☐

* Other problems:	Number of visitors:	
	Tourists	Partners

Composition of the patrol (incl guides, military): Head of team Others:		**Remarks:**
	Signature:	

Appendix 4: New gorilla data sheet (example of Nkuringo group)

Date:	**Start time:**	**End Time:**	**Team leader:**
Nests location: Number of nests: How many days old? Name of Place: GPS 35M____________________ , UTM_____________________ Altitude _____ m			**Other staff:**
Observation location Name of Place GPS 35M____________________ , UTM_____________________ Altitude______ m			**People Present** _____ Swift _____ Tracker/guide _____ Porters _____ Tourists _____ Other : _______________________

Vegetation type: habitat where the observations were made	**Type of activity** (in general)	**Food Items** (tick only the food items listed below)
__ Bamboo __ Closed forest __ Open forest __ Outside park	__ Eating __ Group interactions __ Playing __ Charging __ Moving __ Rest period	□ Dirt □ Dung □ Ants □ Drinking water □ Mushrooms □ Cultivated foods

Gorilla	**System**	**Comments**

General comments:

Gorilla	**Seen?**	**Body**	**Activity**	**Respiratory**	**Skin Hair**	**Discharge Head**	**Discharge Other**	**Stool**	**Other**	**Comments: (e.g. fighting)**
Nkuringo (SB)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Safari (SB)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Bikingi (BB)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Kisoro (BB)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Rafiki (BB)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Kasotora (AF)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Kwitonda (AF)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Mama x-mas (AF)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Samehe (AF)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Karibu (SA)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Kirungi (BB)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Bahati (BB)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Posho (SA)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
X-mas (SA)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Kwesima (IN)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Magara (IN)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Rwamutwe (IN)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
Twin (IN)	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	
	Y N	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	Y N A	

Y = Normal; N = Not Seen; A = Abnormal; Body = chest and abdomen; Respiratory = nostrils and chest; Skin/Hair = both arms, front and back; Discharge Head = eyes, mouth, nose and ears; Discharge other = anus; stool = defecating during visit