Final Report

Importance of seed dispersal by gorillas and chimpanzees in Bwindi Impenetrable National Park in Uganda

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Overview of the Project

In most tropical forest, primates comprise the largest percentage of arboreal, mammalian biomass and move large numbers of seeds (Wrangham *et al* 1994; Chapman & Chapman, 1995). The role of primates as seed dispersers is probably particularly important for large seeded or hard-husked fruit species, which may be inaccessible to small, arboreal taxa (Andresen, 2000). The conservation of primates is thus key to maintaining effective seed dispersal of some species (Andresen, 2000). While it is difficult to quantify the direct and indirect ecological impacts of primate extinction, a glimpse of what may happen is visible. Chapman & Chapman (1995) estimated the potential loss in plant biodiversity that would result if all the large bodied seed dispersers (i.e. primates) were removed from the Kanyawara study area of Kibale. They assumed this would result in all fruit dropping below parent trees. On the basis of presence or absence of seedlings and saplings under adults, they concluded that 60% of the 25 tree species they studied would ultimately be lost if large seed dispersing animals-such as primates were removed. More than a third of all forest tree species in Kibale have seeds dispersed by primates and 42% of primates dispersed species have some direct utility to local people, including food, medicine and fodder (Lambert, 1998). These results demonstrate the complex link among plant species, dispersers and the human populations that rely on forest, forest edge and forest fragments. The conservation of primates species is an important goal in itself. In working to ensure their protection, we gain indirect, concomitant benefits by maintaining seed dispersal and the regeneration of economically important trees.

Mountain Gorillas and chimpanzees occur together in only one forest in Africa BINP. This sympatric influence patterns of habitat use, seed dispersal and seed establishment. Seed dispersal by apes have been found to be viable; chimpanzees-Takasaki 1983 & Wrangham *et al* 1994; Bonobos-Idoni 1986 suggested that passage through a chimpanzees gut improves percentage germination and shortens the time of germination.

In this study, I assessed seed dispersal rates for chimpanzees and gorillas in BINP of western Uganda and considered their importance. The relative abundance of the species of seed dispersed by gorillas and chimpanzees was assessed and viability described from the phonological status of all important and dependant trees. I also compared the viability and rates of germination of seeds collected from gorillas and chimpanzees dung with those of non-dispersed seeds collected from parent trees.

Methods

The study was conducted at two locations separated by 18Km within Bwindi Impenetrable National Park (0053" – 1008"N, 29035" – 29050"E) in south-western Uganda between April 2004 to August 2005. Bwindi is an afromontane rain forest, 331Km^2 in size, ranging from 1160 – 2603 meters in altitude characterized by steep-sided hills, peaks, and narrow valleys (Mcneilage *et al* 2001).

The data was collected on four habituated gorilla groups, ranging in size from 7-24 individuals, excluding infants and one habituated chimpanzee group of 28 individuals. Three gorilla groups, Mubare, Habinyanja and Rushengura ranged around Buhoma (1450 – 1800m) in the western section of the park (Fig 1). The fourth gorilla group named Kyanguriro and one chimpanzee group range near Ruhija (2100- 2500m) in the eastern section of the park (Fig 1). Both groups are habituated for research purposes.

Collection if dung samples

Both chimpanzees and gorilla dung was collected between May 2004 and Jan 2005 from their night nests. For the chimpanzee dung, it was collected opportunistically in trails and below their nest on ground. The dung samples were placed in plastic bags, and transported to the field camp. Each dung sample was weighed and washed, all seeds counted and identified. All seeds were identified and dried for storage. GPS points were taken on the nest sites and on trail where the samples were collected.

Effects of gut passage on Germination

In March 2005, seeds, seeds were germinated to determine the viability of the seeds passed by gorillas and chimpanzees. Representatives of seeds of all known species or types from fecal materials of both chimpanzees and gorillas were planted in a forest soil nursery beds individually together with seeds collected from the parent trees in similar conditions. The number of days required for germination for chimpanzees and gorillas dispersed seeds were compared with that required for seeds collected directly from parent trees.

Tree abundance

In order to determine the temporal availability of fruit resources, I recorded phonological data on 251 trees of 26 species from Ruhija are and 357 trees of 34 species in Buhoma area. Approximately the same time at the beginning of the each month (1-2-3) and the middle of each of each month (14-15-16), from each tree, we recorded the presence of unripe fruits, ripe fruits, new leaves and flowers using an abundance score from the following categories between zero and four (0=0%, 1= 1-25%, 2= 26-50%, 3=51-75%, 4= 76-100%). The DBH of each tree was measured, their location pinpointed by a GPS reading and its height and crown diameter estimated and recorded.

Results and discussion

Seed dispersal rates by chimpanzees

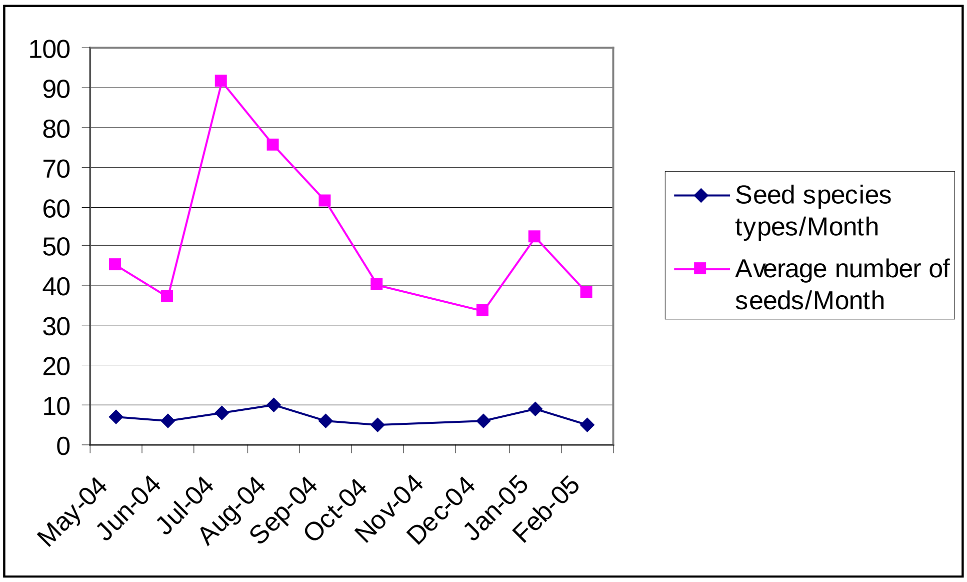
A total of 879 chimpanzees dung samples were analysed. On average, dung samples weighed 71.9gms (D= 51.67, range = 284 gms N=864). 1.74%of the samples had no seeds in them. Seeds occurred in 98.26% of all chimpanzees samples collected.

The number of seed species or types of seeds found in the chimpanzee dung ranged between 1 to 8, N=879. The length of seeds found in the dung ranged from less than 1mm (e.g. figs) to approximately 1.58mm (*Drypetes geradii*). A total of 26 species of seed types per dung were identified. Seeds of *Ficus spp* were most frequently occurring in chimpanzees' dung (26.6%) followed by *Olinia Usambarensis* (Table 1).

Table 1: Chimpanzees seed species

Species	Species Frequency	%weight of dung with seeds	Number of seeds/dung sample
Allophyllus abisinicus	40	2.73	3.40
Allophyllus Macrobotrys	19	1.45	1.7
Chysphyllus Sp	2	0.26	0.10
Coffea Eugenioides	3	0.42	0.34
Drypetes geradii	147	17.40	35
Ficus Distipulata	56	6.64	common
Ficus Natalensis	164	17.34	common
Ficus sp	15	1.67	common
Impatieus sp	1	0.21	0.26
Keetia Guenzii	2	0.15	0.2
Marsa Lanceolata	1	0.12	0.03
Myrianthus holstii	8	0.89	0.08
Olea capensis	8	1.05	0.70
Olinia usambarensis	207	25	40.30
Paridiantha Callicerpoides	24	3.66	2.30
Pittosporum Mauii	7	0.60	0.12
Pleiocarpa Pycnentha	5	0.22	0.10
Prunus Africana	46	4.70	4.70
Psychotria mahonia	12	0.60	5.10
Rentidia orientalis	2	0.25	0.72
Rubus sp	2	0.30	0.52
Rytiginia Kigeziensis	26	3.10	3.90
Salacia elegaus	12	1.60	0.32
Syzigium guinensis	5	1.01	0.15
Syzigium cordatum	5	0.70	0.36

Fig. 2. Relationship between seed species types and their number per month



The months of July, August, and September 2004 had a lot of seeds in the dung samples compared to other months which correspondences with a lot of seed species in the same months (Fig 2). This shows a direct relationship that many seed species increases with number of seeds In the dung samples.

Effects of Chimpanzees gut passage on germination.

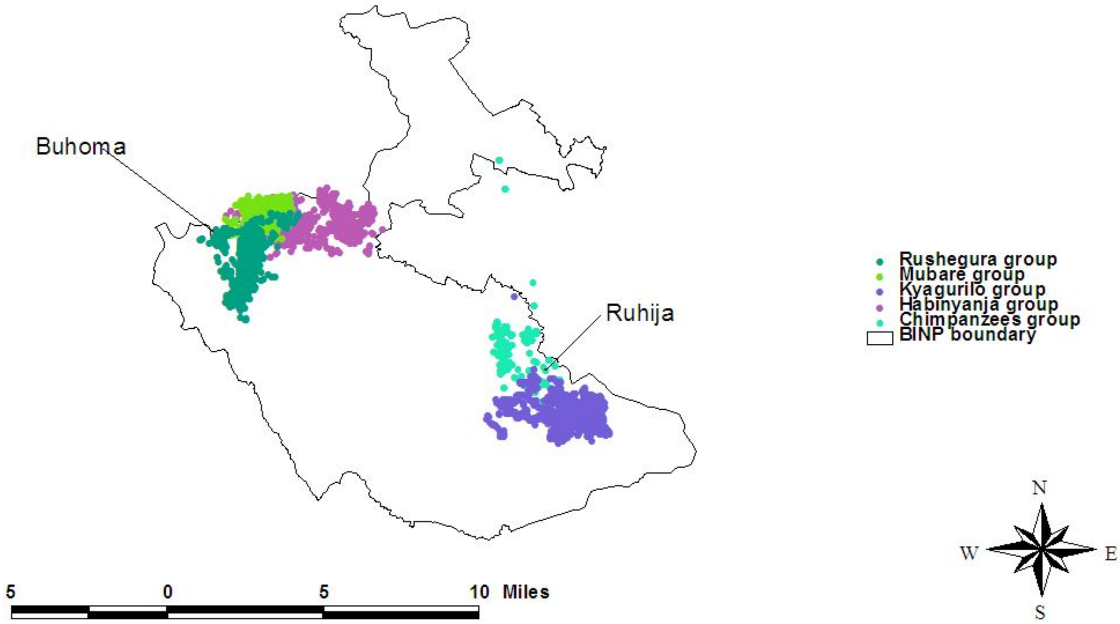
Table 2: Chimpanzee seed species germination trials

Seed species	Number of seeds from dung samples	Number of seeds from Parent trees	Number of each seed category planted
Allophyllus Abbysinica	4 (45)	8 (45)	45
Allophyllus macrobotrys	7 (16)	3 (16)	16
Drypetes Gerandii	0 (30)	0 (30)	30
Ficus Destipulate	0 (>100)	0 (>100)	>100
Ficus Natelensis	0 (>100)	0 (>100)	>100
Ficus sp	-	-	>100
Olinia usambarensis	0 (35)	0 (35)	35
Prunus Africana	7 (42)	1 (42)	42
Rentidia Orientalis	0 (30)	0 (30)	30
Rytiginia Kigenziensis	8 (38)	2 (38)	38

Allophyllus macrobotrys form the dung had a high a germination rate with 43.8% followed by *Rytiginia Kigeziiensis* (21%) then *Prunus Africana (16%).* The time between planting of chimpanzee-dispersed seeds and the first sign of germination averaged 129 days. Among 10 seed species planted, four germinated. The failure of many seeds could have resulted due to decay, young seeds from the dung and monkeys uprooted and exposed seeds in the nursery. 36.4% of the planted seed species germinated. There was a high percentage of germination from Dung seeds (22%) than from parent seeds (5.3%) Table 2. This evidence suggests that passage through a chimpanzee's gut improves percentage germination.

Ranging patterns of the chimpanzees and gorillas in Ruhija and Buhoma.

Map1. Ranging patterns of chimpanzees and gorilla in BINP

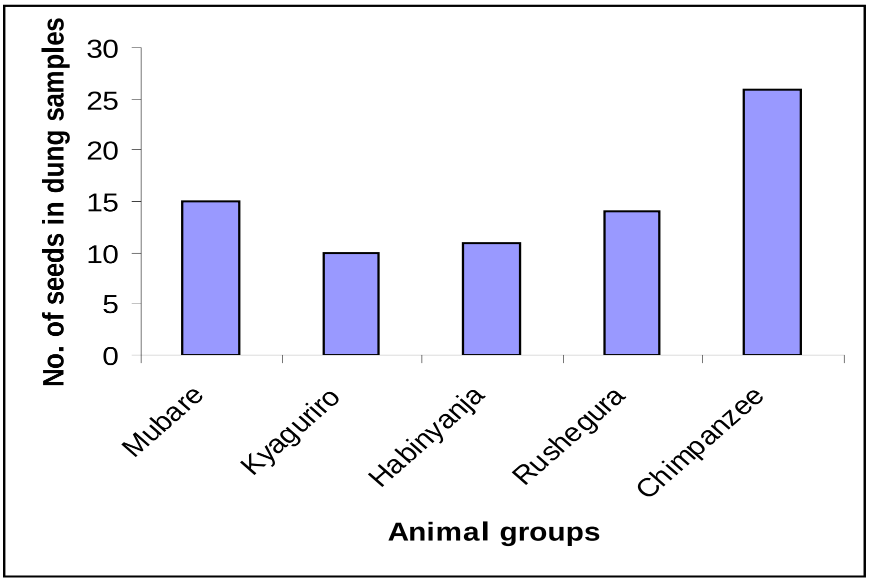


Map1 shows the locations of the two study sites and the ranging patterns of four habituated gorilla groups and one habituated chimpanzee group and how they overlap.

Table 3: Comparison of mountain Gorillas and Chimpanzees Seed dispersal Rates

Variables	**Gorilla Groups**				
	Habinyanja	Rushegura	Mubare	Kyanguriro	Chimps
Average weight (gms)	154.46	161.10	155.27	148.53	71.9
Weight range (gms)	21-500	21-530	33-505	27-600	5-284
S.D	60.87	60.079	50.00	35.76	51.67
Number of samples	1190	1159	1103	1101	879
Number of seed species	16	18	17	12	26
%age of samples with no seeds	13%	30.72%	21.74%	21.51%	1.74%

Fig 2. Number of seeds found in each primate dung samples



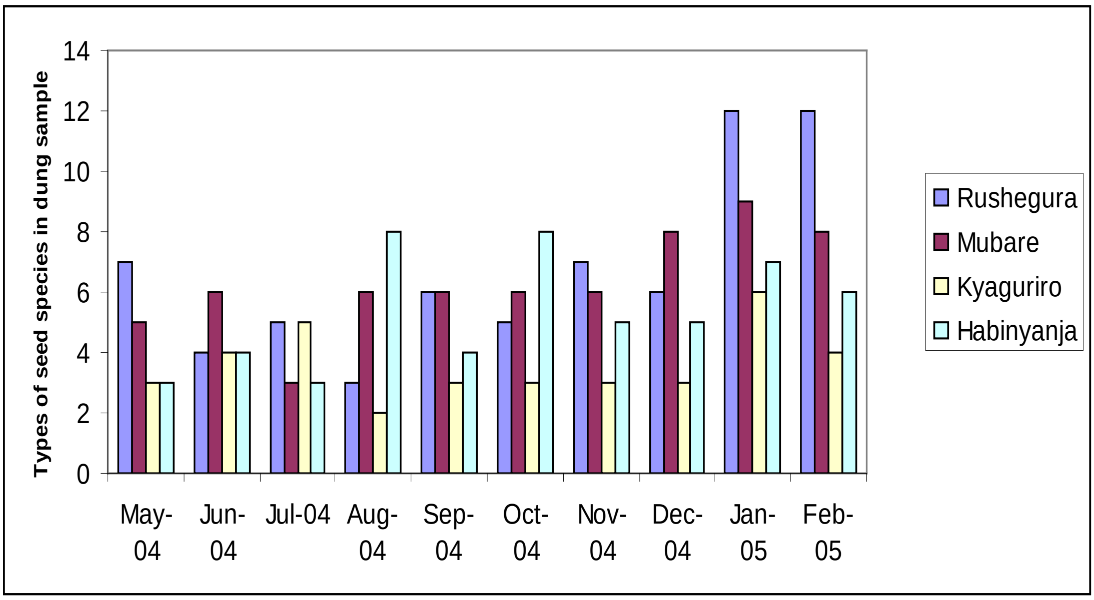
A total of 4553 gorilla dung samples were collected from 4 habituated gorilla groups and analysed compared to 879 dung samples of chimpanzees. Chimpanzees had many seed species compared to other gorilla groups and had very few samples with no seeds. Chimpanzees climb higher trees than gorillas, eat a lot of fruits than gorillas and mostly depend on fruits compared to gorillas, this explains a lot of seeds in the chimpanzees dung than in gorillas.

Table 4. Gorilla seed species

Species	Seed species frequency in gorilla groups			
	Mubare	Habinyanja	Rushegura	Kyaguriro
Aframomum angolansis	5	2	5	
Allophyllus sp				24
Chrosophllus sp				42
Ficus sp				1
Myrianthus holstii	233	271	237	46
Olea				2
Olinia				93
Rubus sp				1
Aframomum sangiunum	11	11	10	
Cassine aethiopiea	273	303	177	2
Drypetes gerradii			15	
Ficus capensis	21	25	53	
Ficus sp	53	37	46	
Galiniera coffeoides	12		41	
Memecylon jasminoides			10	
Prunus Africana	13	108	23	
Trichilia prieureana	13		43	
Grewia pubescens	1			
Maesa lanceolata	1	9		
Rubus sp	7			
Psychotria kirkii		6		

Only two seed species of *Myrianthus holstii,* and *Cassine aethiopiea* seeds were dispersed by all gorilla groups.

Fig 3. Number of seed species found in each gorilla group dung samples



Mubare, Habinyanja and Rushegura gorilla groups in Buhoma fed more on *Cassine aethiopiea followed by myrianthus holstii species* than Kyaguriro gorilla group in Ruhija (Table 4). This could be due to different fruiting season of *cassine aethiopiea* and *myrianthus holstii* tree species at these two different sites that have different altitudinal ranges. Buhoma gorillas fed on many different fruit species compared to Kyaguriro group in Ruhija.

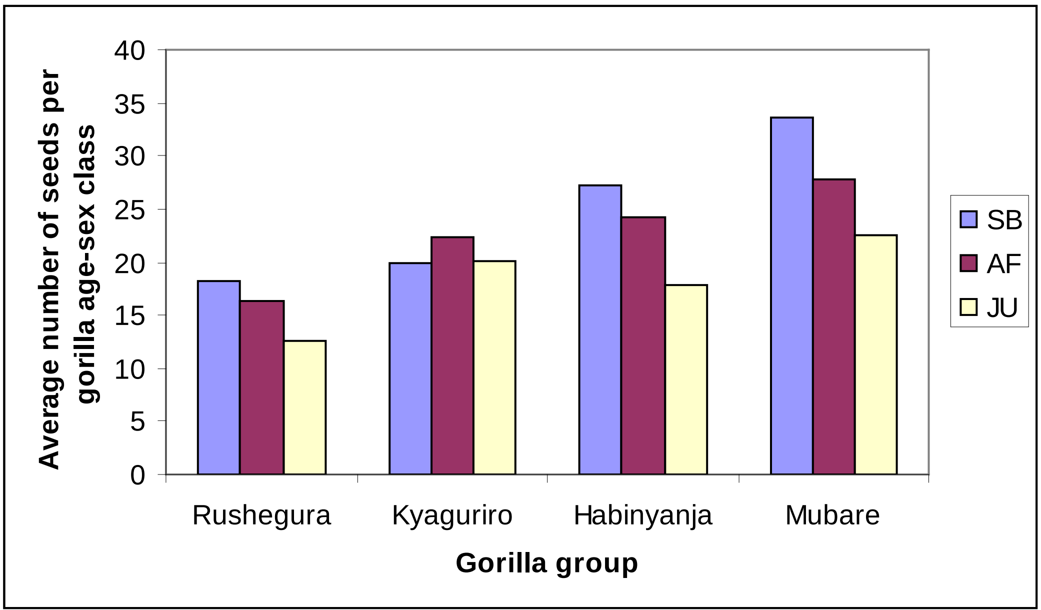
Effects of gorilla gut passage on germination

Table 5: Mountain Gorilla seed species germination trials

Seed Species	Number of seeds from dung samples	Number of seeds from Parent trees	Number of each seed category planted
Cassine aethiopica	**1 (30)**	**0 (30)**	**30**
Ficus capensis	**0 (>100)**	**0 (>100)**	**>100**
Myrianthus holstii	**5 (20)**	**1 (20)**	**20**
Prunus Africana	**11 (35)**	**4 (35)**	**35**
Psychotria kirkii	**3 (45)**	**0 (45)**	**45**
Syzygium guineense	**0 (30)**	**0 (30)**	**30**
Trichilia prieureana	**0 (40)**	**0 (40)**	**40**

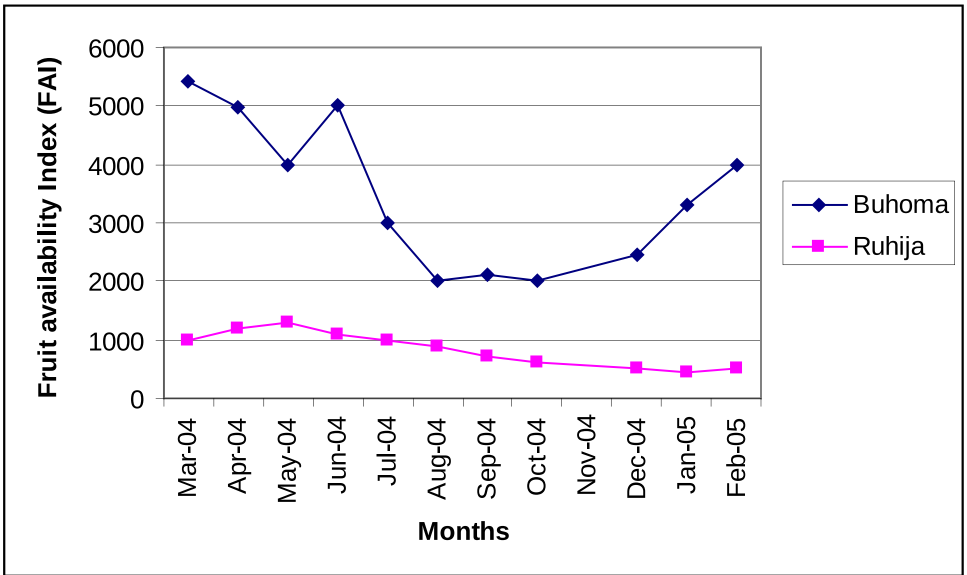
Prunus Africana seeds from the gorilla dung had a high a germination rate (31.4%) followed by *Myrianthus holstii* (25%). The time between planting of gorilla-dispersed seeds and the first sign of germination averaged 92 days. 57.1% of the planted dispersed seed germinated while 28.60% of seeds of non-dispersed seeds germinated. There was a high percentage of germination from dispersed seeds (22%) than from parent seeds (5.3%) Table 5. This evidence suggests that passage through a chimpanzee's gut improves percentage germination.

Fig 4. Number of seed species per gorilla age-sex class



Many seeds were found in Silverback dung samples followed by Adult female and then juveniles.

Fig 5. Availability of fruit resources in BINP



Fruit availability, as measured by the FAI index. Which incorporates phenology, tree density and tree d.b.h was significantly greater at buhoma than Ruhija (t-test= 2.2, P> 0.001) with an approximately fourfold variation in fruit availability across the months (Fig. 5). The total fruit availability for Ruhija was less than half of Buhoma's total fruit availability. The lowest month of fruit availability in Buhoma was greater than the highest month of fruit availability in Ruhija. There was a more pronounced seasonality of fruit availability in Buhoma than Ruhija, but both sites had approximately double the amount of fruit available in the months of highest availability compared with that of the lowest.

Chimpanzees versus mountain gorilla seed dispersal

To compare chimpanzee seed dispersal with dispersal by gorillas, I calculated the number of seeds per dung for the four gorilla groups and one chimpanzee group at two different sites; Ruhija; Chimpanzees (N=26) Kyaguriro (N=12) and Buhoma site; Mubare (N=17), Habinyanja (N=16) and Rushegura (N= 18). This indicates that chimpanzees play a more significant role in primary seed dispersal than mountain gorillas in Bwindi Impenetrable National Park. These findings demonstrate the potential importance of great apes in the maintenance and regeneration of tropical forest, and indicate the importance of understanding the processes in structuring tropical forests when making informed conservation plans.

Research Impact

- There is now a better understanding of gorilla and chimpanzee ecological requirements in terms of sympatric influence, pattern of habitat use, seed dispersal and important role these primates play in regeneration through their gut influence on seed germination. This information was needed for endangered primate species conservation in Uganda. This has contributed directly to creating accurate primate management plans and increased our knowledge of the importance primates at dispersing seeds.
- Six rangers, one warden and 3 local field assistants were trained on data collection, entry, and analysis. They were trained on Ms excel spreadsheet and ArcView GIS for mapping the ranging patterns of primates, distribution and extent of illegal activities in the park. Uganda Wildlife Authority has a ranger based data collection and monitoring program that has compiled a great deal of data on habituated gorillas and during anti-poaching patrols in the park. The Park Rangers lacked the capacity to collectly record and enter the data while the Park Wardens lack the skills to analysis the data for management purposes. This project has helped the park staff acquire the skills of data recording, entry and analysis.
- One draft publication has been submitted to Journal of African ecology for publication. This will increase on information dissemination.
- The findings from this research have been presented to Uganda Wildlife Authority staff, NGO staff and researchers in the area during the annual researcher’s symposium held in Buhoma, Bwindi Impenetrable National Park headquarters.
- I, the principal investigator has gained a lot of experience on how to carry out applied and scientific research and communicate results until the end users.

Acknowledgement
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Reference

Andresen, E. (2000) Ecological roles of mammals; the case of seed dispersal. In: Entwistle, A. and Dunstone, N. (Eds) *Priorities for the Conservation of mammalian Diversity.* Cambridge University Press, Cambridge, UK, pp. 12-26.

Chapman C.A. Chapman L.J. 1995. Survival without dispersers: Seedling recruitment under parents. *Conservation Biol* 9: 675-678

Takasaki H. 1983. Seed dispersal by chimpanzees: a preliminary note. Afri st Monogr 3:105-108.

Tutin, CEG, Williamson, E.A, Rogers ME, & Fernadez, M.1991. A case study of a plant-animal relationship: Cola lizae and lowland gorillas in the Lope' reserve, Gabon. Journal of Tropical Ecology 7:181-199.

Lambert, J.E (1998) Primate frugivory in Kibale National Park, Uganda, and its implications for human use of forest resources. *Africa Journal of Ecology 36,* 234-240.

Wrangham.RW, Chapman CA, Chapman LJ. 1994. Seed dispersal by forest chimpanzees in Uganda. J Trop Ecol 10: 355-368.