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A preliminary assessment of large mammal and bird use of different habitats in Bwindi Impenetrable National Park

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Abstract

Understanding species distributions, habitat requirements, and population trends is helpful for implementing effective conservation. But expense often prevents such evaluations. Here, we present a preliminary assessment for a low-cost method – road-side observations – to see how effective it can be. The bamboo zone of Bwindi Impenetrable National Park is restricted, covering 0.3% of park area yet is poorly known. Our study evaluates the use of the bamboo zone and surrounding forest by species of large mammals and large ground birds. Data were collected while driving a road section running through this zone. During 416 trips, seven species of mammal and one bird were recorded. Distributions for most species were significantly nonrandom in both space ($P < 0.02$) and time (Hour of day: $P < 0.040$; Month: $P < 0.0001$) for all species but black-fronted duikers and blue monkeys for which $0.085 > P > 0.050$ for month. Of the species observed, francolins were more frequently seen in the zone of visible bamboo than the nonbamboo zone ($P = 0.002$). Black-and-white colobus, L'Hoest's monkey, and jackals were more common in nonbamboo forest ($P \leq 0.05$). Road sightings have potential for low-cost habitat use assessments and monitoring.

Key words: bamboo forest, bio-monitoring, Bwindi, low-cost-surveys, restricted habitat, tropical forest

Résumé

Le fait de comprendre la distribution, les exigences en matière d'habitat et la tendance des populations d'espèces est très utile pour pouvoir les conserver efficacement. Mais les dépenses nécessaires empêchent souvent de faire de telles évaluations. Nous présentons ici une première évaluation d'une méthode peu coûteuse – des observations faites à partir de routes – pour voir quelle peut être son efficacité. La zone de bambous du Parc National de la Forêt impénétrable de Bwindi est peu étendue – elle couvre quelque 0.3% de la superficie du parc - et pourtant elle est peu connue. Notre étude évalue la fréquentation de la zone de bambous et de la forêt qui l'entoure par les espèces de grands mammifères et de grands oiseaux terrestres. Nous avons récolté des données tout en parcourant en voiture une portion de route qui traverse cette zone. En 416 voyages, nous avons dénombré sept espèces de mammifères et une espèce d'oiseau. La distribution de la plupart des espèces n'était significativement pas aléatoire, tant en ce qui concerne l'espace ($P < 0.02$) que le temps (heure de la journée: $P < 0.040$; mois: $P < 0.0001$) pour toutes les espèces à l'exception des céphalophes à front noir et des cercopithèques à diadème pour lesquels $0.085 > P > 0.050$ pour le mois. Parmi elles, les francolins étaient observés plus souvent dans la zone de bambou visible que dans la zone sans bambou ($P = 0.002$). Le colobe guereza, le cercopithèque de l'Hoest et les chacals éraient plus fréquents dans la forêt sans bambou ($P \leq 0.05$). Les observations faites à partir des routes offrent des possibilités pour évaluer et suivre à faible coût l'utilisation de l'habitat.

Introduction

Conservation research should address practical conservation needs and goals. Unfortunately, across much of the tropics, the finance available to support such activities is severely limited, and the demands on conservation funds are diverse. But a more systematic approach to recording everyday observations may be one means to make better use of available resources and opportunities (Meijaard & Sheil, 2007).

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Practical conservation needs have been met in Ugandan forests through understanding species distributions (Davenport, Howard & Matthews, 1996; Olupot & Plumptre, 2008). In Bwindi, several studies have examined species distributions. For example, mountain gorillas *Gorilla beringei beringei* Matschie (McNeilage *et al.*, 1998) and elephants *Loxodonta africana* Blumenbach (Babaasa, 2000) occur in the southern but not northern sector of the Park. Other studies in the same park have shown edge-related distributions (Carnivores – Andama, 2000; plants – Olupot, 2009; Olupot, Barigyira & McNeilage, 2009; and birds – Bataamba, 1990). They have also documented species affinities with the bamboo zone, a zone covering <1% of the park (elephants – Babaasa, 2000; blue monkeys *Cercopithecus mitis* Wolf – Butynski, 1984; carnivores – Andama, 2000; butterflies – Omoding, 1992; small mammals – Kasangaki, Kityo & Kerbis, 2003). Although each study provides valuable data sets, each is costly.

This low-cost study was performed to assess habitat selection by species of large mammals and ground birds occurring in the bamboo zone and surrounding non-bamboo forest. Such information is potentially useful for interpreting species trends and distribution for the Park's law enforcement and tourism programs, as well as for the monitoring programs of the Institute of Tropical Forest Conservation (ITFC). Frequent road sightings of large mammals and birds in this forest suggested the potential of road trips through this zone for the assessment of habitat use patterns and population monitoring. We took advantage of people frequently using this road by encouraging the collection of low-cost data. This study examines whether the road-based observation data were of value for answering the following questions: (i) how does the use of bamboo forest compare with use of adjacent high forest for each species? (ii) how do sightings of each species vary between months? (iii) how does the likelihood of sighting the different species vary through the hours of the day? (iv) how do the different species compare in the likelihood of being sighted on any given trip? and (v) is such data consistent enough to use as a means of monitoring?

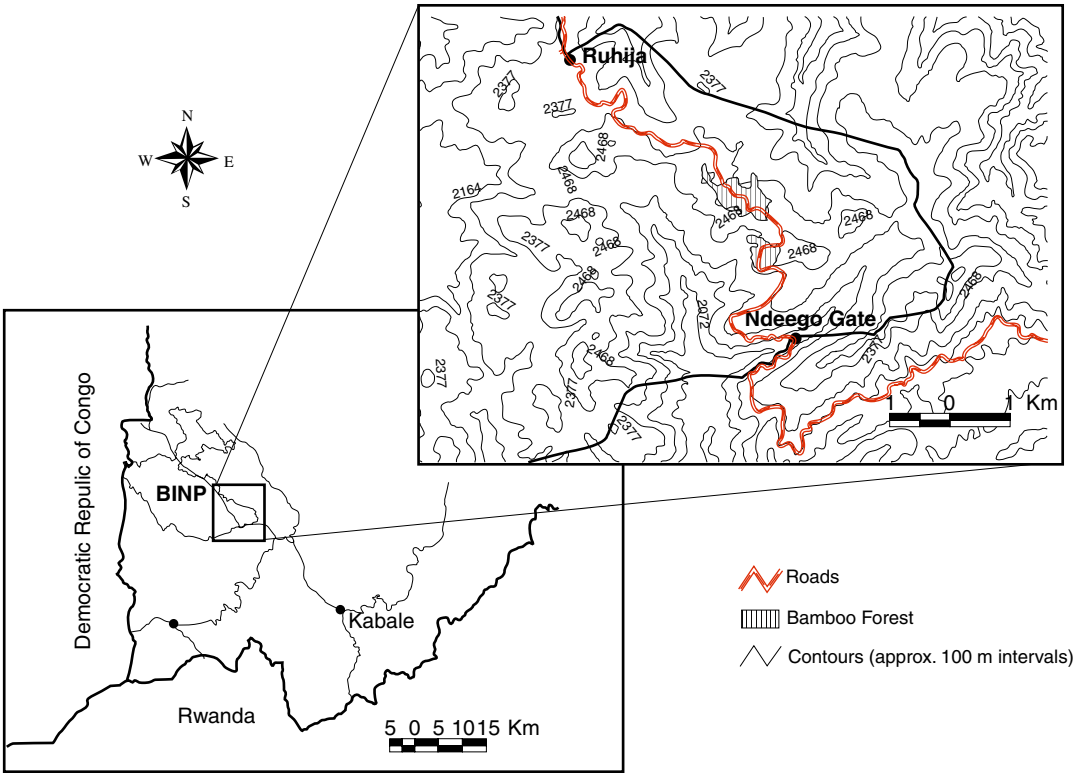

Fig 1 Map of south-western Uganda showing the location Bwindi Impenetrable National Park and road section (Inset) studied

Materials and methods

Study area

Bwindi Impenetrable National Park (0°53′–1°08′S, 29°35′–29°50′E) is located in south-western Uganda (Fig. 1). The park, 321 km^2 in size, was originally a forest reserve, upgraded to National Park status in 1991. It is located on rugged terrain and elevation is varied, tilting from 2607 m in the southeast to 1190 m in the northwest (Butynski, 1984).

The park is traversed at two points by a motorable road. Researchers at ITFC frequently use the high-elevation section on their way to and from the nearby town of Kabale (Fig. 1).

Located in the Albertine Rift, the Park is rich in both fauna and flora. At least 135 species of mammal and 381 bird species have been recorded in this park (Plumptre *et al.*, 2007). Large mammals include seven diurnal primates (the mountain gorilla, *G. g. beringei*; chimpanzee *Pan troglodytes* Blumenbach; baboon *Papio hamadryas anubis* Lesson; the black-and-white colobus, *Colobus guereza* Rüppell; L'Hoest's monkey, *Cercopithecus l'hoesti* Sclater; the blue monkey, *C. mitis*; and the red-tail monkey, *Cercopithecus ascanius* Audebert) (Butynski, 1984).

Other large mammals include elephant *L. africana*, bushbuck *Tragelaphus scriptus* Pallas, three members of the family cephalophinae, two members of the family Suidae, one canid and three felids.

Large birds recorded in this park include the crested guineafowl *Guttera edouardi* Hartlaub, handsome francolin *Francolinus nobilis* Reichenow, and the scaly francolin *Francolinus squamatus* Cassin (Davenport, Howard & Matthews, 1996). The bamboo zone, a 1 km^2 mixed forest of bamboo and trees, is located between 2400 m and 2600 m (Butynski, 1984) above sea level.

Field methods

We marked the road section (between the Park gate at Ndeego and Ruhija Park Ranger's camp, Fig. 1) at 0.4 km intervals beginning at the 0.0 km mark near the gate and ending at 12.4 km near the ranger's camp at Ruhija. This resulted in 31 0.4 km intervals. Narrower intervals or use of GPS could improve resolution. Between meaningful resolution and convenience, 400 m intervals were considered a simple compromise – a wish to not burden the observers. Continuous bamboo was only visible from the road along the section between 2.4 and 8.4 km (i.e. in 15 0.4 km intervals). The study focused on large diurnal mammals and terrestrial birds.

Datasheets were filled out mainly by ITFC researchers (>90% of the records) and other interested road users. The datasheets were simple and had accompanying instructions and examples. Upon arrival at the 0.0 and 12.4 km marks, the travellers recorded the date and time of the day. As they progressed, they recorded the identity and numbers of animals they saw, the time of day seen, and the road intervals where they were seen. For francolins, we did not distinguish between *F. nobilis* and *F. squamatus,* and all francolin observations were simply recorded as 'Francolin' (and treated as a single 'species'). For elephants, presence or absence of fresh sign (e.g. tracks crossing the road and dung on the road made or deposited over the last 12 h) at each road interval was recorded. Multiple records of same elephant sign observations within a given distance interval were counted as a single observation in the analyses. Data were collected from May 2001 to August 2004 altogether resulting in 416 trips (314 with observations and 102 without observations).

Data analysis

All statistical analyses and graphical displays were performed using SYSTAT Version 10.2 (SYSTAT Software,Inc., Richmond, CA, USA).

Patterns were inferred by graphical presentation. Use of bamboo and nonbamboo forest was determined by plotting average number of individuals seen or (for elephants) presence and absence of signs per 0.4 km section per trip against distance from Ndeego Gate. Average numbers per section per trip were calculated by dividing the total number of sightings in each 0.4 km section by the total number of trips made through the 12.4 km road length including trips for which no individuals were seen to correct for differences in the number of trips between months and at different hours of the day. Graphical plots were 4-period moving averages. Moving averages were preferred to line plots for better clarity, and 4-period averages were preferred to 2-, 3- or 5-period averages as they produced the best smoothing result while maintaining valuable detail. Differences in the use of bamboo and nonbamboo forest were further evaluated with a Mann–Whitney *U*-test after testing for normality. Nonrandomness in distribution along the road was

evaluated by testing against a Poisson distribution and species correlations using Pearson's pairwise correlations and Bonferonni probabilities.

To display hourly and monthly patterns, we divided the total number of individuals or signs seen during each hour or month by the total number of number of trips originated during the hour or number of trips run during the month (including trips in which no animals or for elephants, signs were seen). We also tested whether hourly or monthly variations in sightings of each species differed from what would be expected if the variations were random by comparing observed and expected values. We further explored possibility of temporal correlations between species to see whether species may be responding to some common but undetermined phenomena. To determine the overall likelihood of each species (or fresh sign for elephants) being sighted on a given trip, the number of presence records for each species per trip was divided by the total number of trips made during the entire course of the study.

Results

Species observed

Eight large mammal and large bird species were observed, including black-fronted duikers *Cephalophus nigrifrons* Thomas, yellow-backed duikers *Cephalophus silvicultor* Afzelius, elephant, blue monkeys, L'Hoest's monkeys, black-and-white colobus, side-striped jackals *Canis adustus* Sundevall, and francolins (scalys or handsomes). Gorillas, chimpanzees, baboons, bushpigs, redtail monkeys, guinea fowls, and other species of larger-bodied mammals and birds were not seen. There was pronounced spatio-temporal variation in sightings of most species along the road section as we shall describe in the following sections.

Differential use of forest types

Uneven sighting densities were evident for all species, and both single and multiple peaks were apparent (Fig. 2). The tendency to sight certain species more commonly along given sections of the road and less often in others was significantly different from chance for all species but blue monkeys (Kolmogorov–Smirnov one sample test using Poisson distribution: black-fronted duikers, $P < 0.0001$; blue monkeys, $P = 0.528$; black-and-white colobus,

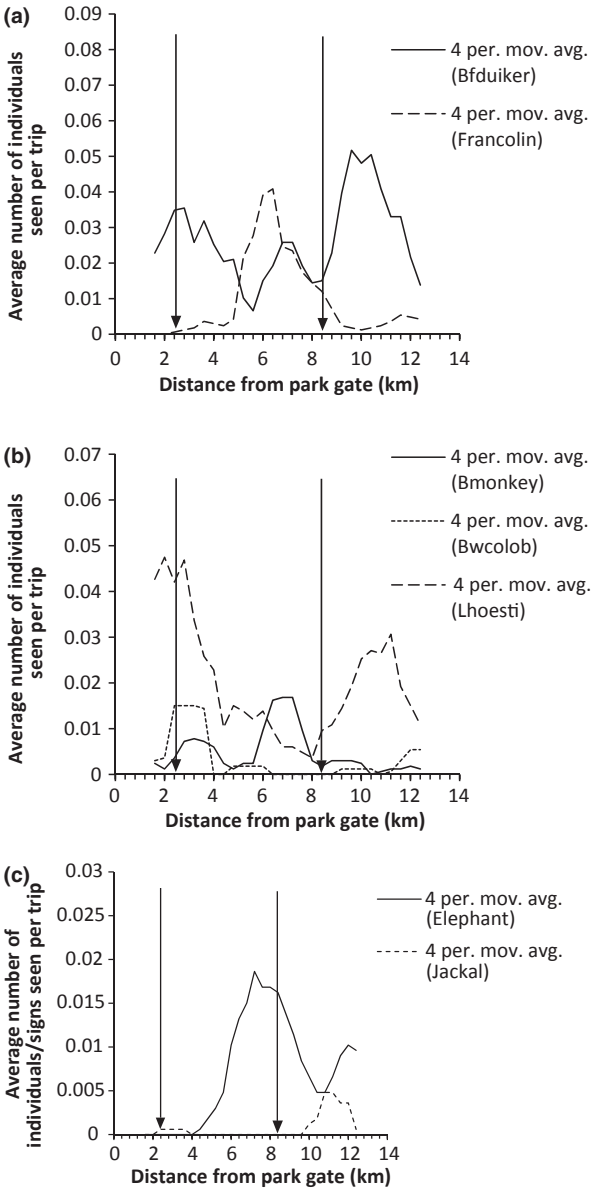

Fig 2 Use of the road section between the park gate (at 0.0 km) and Ruhija (12.4 km) by individual species as shown by the average number of individuals/signs observed per trip. Sections between the arrows represent a stretch of visible bamboo. Trend lines were constructed using four period moving averages

$P < 0.0001$; elephant, $P < 0.0001$; francolins, $P = 0.019$; jackals, $P < 0.0001$; L'Hoest's monkeys, $P < 0.0001$; n = 31 throughout). Sightings of francolins, elephants, and blue monkeys peaked in the bamboo zone. Francolins and elephants had pronounced single peaks, while blue

monkeys peaked twice in the same zone. Other species were more often sighted outside the bamboo zone. Black-fronted duikers had pronounced peaks at either end of the road and a small peak in the middle which has a mix of forest trees and bamboo. Jackals were sighted only at the road ends, while black-and-white colobus sightings were discontinuous but peaked nearer the gate. L'Hoest's monkeys were usually sighted outside the bamboo zone. Despite apparent preference of bamboo or nonbamboo forest by the various species, there were generally no correlations in species locations (pairwise correlations, $P > 0.4$ for all pairwise combinations except elephants and L'Hoest's monkeys which were negatively correlated: $r = -0.540$, $P = 0.036$, n = 31).

Sightings in the bamboo and nonbamboo sections were significant for some species but not others. Francolins were more frequently sighted in the bamboo zone than nonbamboo zone ($U = 44$, $P = 0.002$), while black-and-white colobus monkeys, L'Hoest's monkeys, and jackals were more frequently seen in the nonbamboo zone than bamboo zone ($U = 165$, $P = 0.021$; $U = 169$, $P = 0.052$; $U = 157.5$, $P = 0.021$, respectively). There were no pronounced statistical differences in the sightings of black-fronted duikers, elephants or their sign, and blue monkeys between the two forest zones ($U = 158.5$, $P = 0.127$; $U = 86.5$, $P = 0.176$; $U = 83$, $P = 0.126$, respectively).

Hourly distributions of sighting incidences

On average, 34.5 (SD = 3.89) trips were initiated on each of the 12 h of the day, but more in the morning hours and evenings than afternoons. The lowest number of trips (17) was initiated at 13.00 hours and the highest (62) at 18.00 hours (Fig. 3).

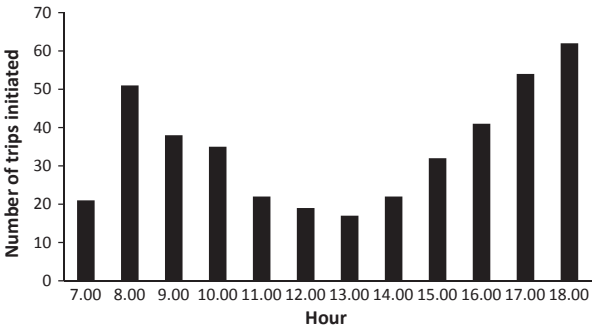

Fig 3 Number of road trips initiated during each hour

Sightings of individual species varied through the day (Fig. 4). The tendency to sight each species (or for elephants fresh sign) more during certain hours of the day than others was significantly different from random for all species (Table 1). Blue monkeys were almost equally encountered at all hours except late evening, but L'Hoest's monkey and black-and-white colobus monkeys were usually seen after 10.00 hours. Black-fronted duikers were frequently seen early in the morning, mid afternoon, and in the evening, and francolins were usually seen during the early morning and late afternoon hours, while Jackals were mostly seen early in the morning and later in the evening. Sightings of fresh elephant sign were usually made during the morning hours. There were no by species correlations by time of day ($P > 0.4$ for all pairwise combinations).

Monthly distributions of sighting incidences

On average, 34.7 (SD = 3.93) trips were conducted each month, with the lowest (17) run in January and the highest (68) in September (Fig. 5). There was monthly variation in sightings of each species (Fig. 6). Tendency to sight species more in certain months and less in others was nonrandom for all species except black-fronted duikers (Table 1). Black-fronted duikers were usually sighted during February and March, and then from June to November. Blue monkeys were often sighted in August to March, black-and-white colobus January–March but also from May to June and August to October. Fresh elephant sign or individuals were often sighted in November and May but also October and April. Francolins were usually seen in January and February, April–June, and September–December. Jackals were seen at the end and beginning of the year. L'Hoest's monkey sightings were most common in February decreasing consistently through the year (Fig. 6). There were monthly correlations in sightings for all species ($P > 0.8$ for all pair combinations).

Discussion

The nonrandom patterns observed show that our road sightings are effective for characterizing species use of habitat types and likelihoods of sighting them at different times of day and year. Patterns observed for most species are consistent with known habits; habits probably influenced by (i) spatial variation in food distribution,

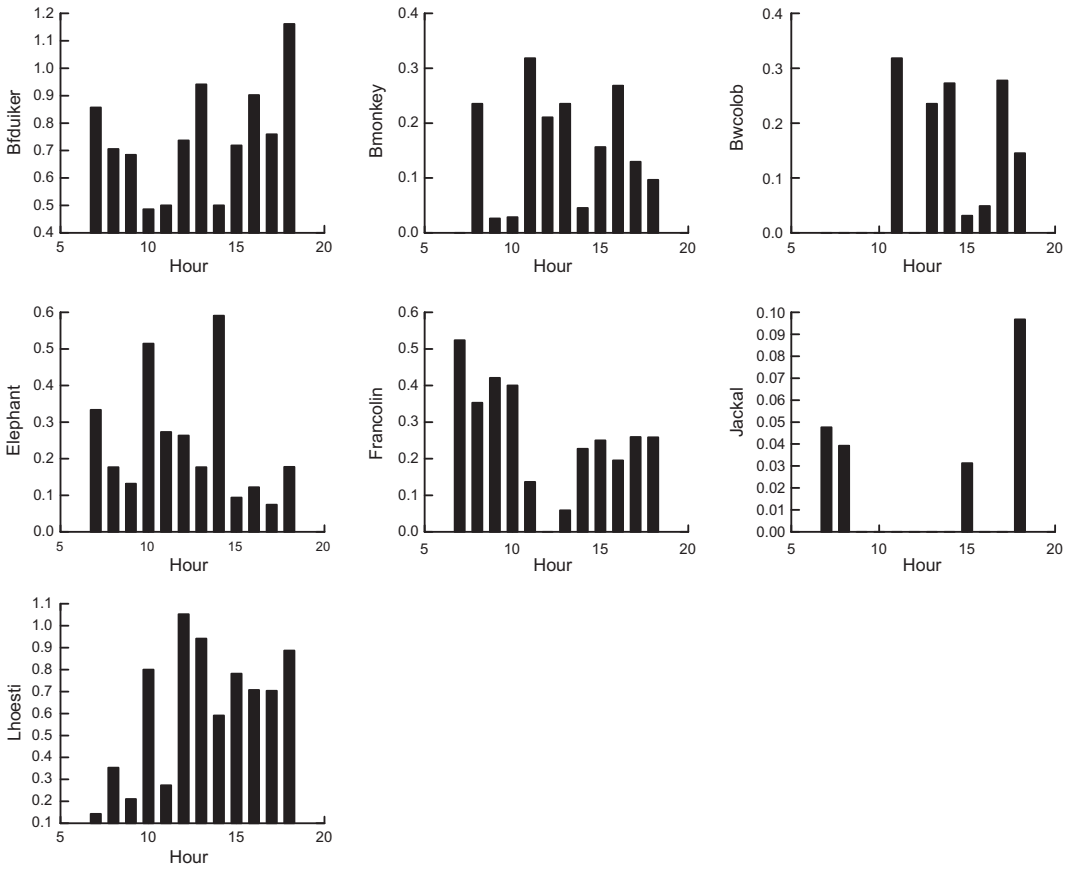

Fig 4 Hourly observations: average numbers of animals sighted (or sign) per trip per hour of day

Table 1 Chi-square test comparisons of observed and expected hourly and monthly sightings for each species along the road section running between Ruhija and Ndeego gate in Bwindi Impenetrable National Park. d.f. = 11 throughout

	Hourly sightings		Monthly sightings	
Species	$\chi 2$	*P*-value	$\chi 2$	*P*-value
Black-fronted duiker	22.476	0.021	17.902	0.084
Blue monkey	26.291	0.006	19.227	0.057
Black-and-White Colobus	53.918	<0.01	34.345	<0.01
Elephant	41.893	<0.01	127.954	<0.01
Francolin	21.732	0.027	74.915	<0.01
Jackal	20.551	0.038	46.364	<0.01
L'Hoest's monkey	47.695	<0.01	122.806	<0.01

temperature conditions, and cover; (ii) monthly changes in temperature, rainfall, and phenology; and (iii) diurnal changes in temperature, humidity, and light conditions.

Of the species that frequented the bamboo zone, elephants or their sign, and francolins tended to be frequently seen during mornings and evenings of the wetter months, while blue monkeys were usually seen throughout the day except mid morning and late evening usually in August to February. For blue monkeys, individuals on high altitudes are known to feed largely on herbs, leaves, and berries, but also on bamboo shoots (Kingdon, 1982). In Bwindi, they are thought to be abundant in the bamboo zone as they eat bamboo shoots (Butynski, 1984). Elephants are reported to frequent the bamboo zone during the wet season to feed on bamboo shoots (Babaasa, 2000). For francolins, the two species are both known to use bamboo zones in their ranges (Crowe, Keith & Brown, 1986; Stevenson & Fanshawe, 2002). *Francolinus nobilis*, which is thought to be a specialist of highland forest (Davenport, Howard & Matthews, 1996), inhabits dense undergrowth from lower edge of montane forest up through Bamboo zone to Afro-

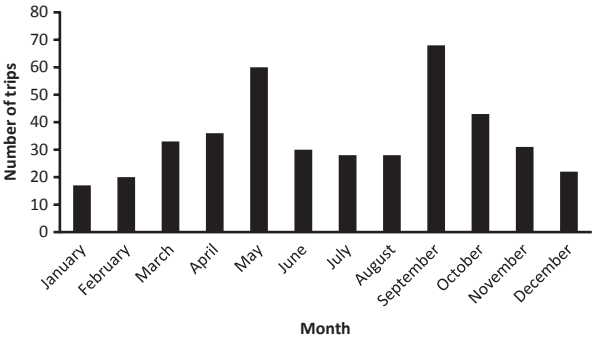

Fig 5 Number of road trips run on any given month

alpine zone at *c.* 3700 m. Pairs and small groups of this species are usually found along edges of roads in very early morning and late afternoon (Crowe, Keith & Brown, 1986). An independent study conducted in the same Park at the same time found a higher rate of occurrence of this species in bamboo forest compared to other forest types (Ssemanda & Fuller, 2005). *Francolinus squamatus* is thought to be a generalist whose range is known to include bamboo zones (Crowe, Keith & Brown, 1986). In this study, francolins were often sighted in wet weather, right after heavy rains and during sustained drizzles.

Of the species that were most frequently sighted away from visible bamboo, black-fronted duikers and black-and-white colobus showed midrange peaking, suggesting frequent use of both habitat types. Frequent occurrence of black-fronted duikers in the bamboo zone is consistent with observations elsewhere. For example, on Mt Elgon, Kingdon (1982) reported these duikers to be commonest at 3000 m where they bred in the thickest parts of the bamboo forest.

For black-and-white colobus, the bamboo zone may be near the limit of their preferred habitat as they are known

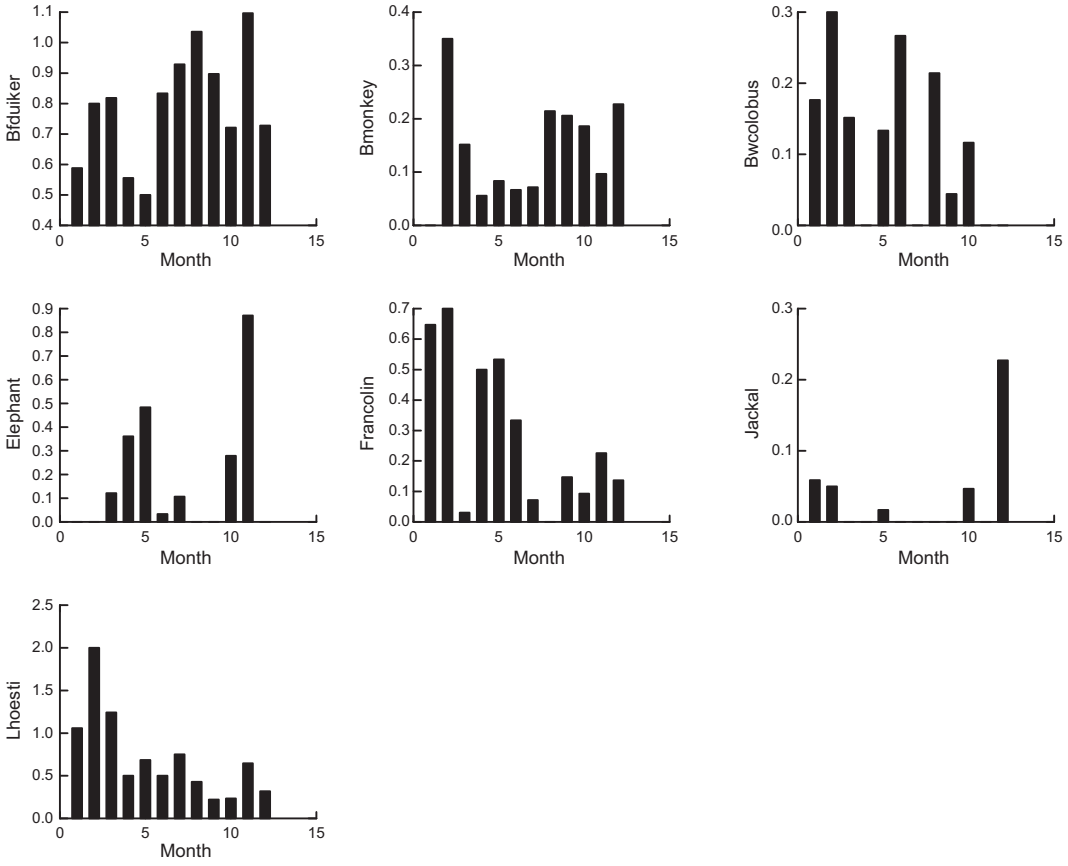

Fig 6 Monthly observations: average numbers of animals (or sign) sighted per trip per month. March–May and September–November are wetter months than others

to occur anywhere from sea level to over 3000 m (Kingdon, 1982). Frequent occurrence in nonbamboo forest near the park gate may be related to foliage availability and occurrence of permanent water. The monkeys prefer fresh growth to older leaves and need water throughout the year (Kingdon, 1982). As the edge zone of BINP is frequently disturbed (Olupot, Barigyira & Chapman, 2009), this may mean a higher availability of fresh growth there, and a permanent stream running across the road in that part of the forest ensures availability of water throughout the year.

For L'Hoest's monkeys, their occurrence at extreme lower elevation road ends makes sense as the bamboo zone defines their upper altitudinal limit (Kingdon, 1982). Variation of monkey sightings during the day was probably related to their diurnal activity.

Jackals were likely found mainly at the road ends as these areas are associated with high human activity. These animals benefit from garbage in human residences (Andama, 2000).

Of the species rarely sighted, sightings may be related to activity patterns, sensitivity to habitat, or occurrence in low populations. Yellow-backed duikers are the largest of Bwindi's duikers but were rarely seen. Of the four times they were reportedly seen during this study, three were in the bamboo zone. In their range, the duikers are known to be locally distributed in pockets of suitable habitat, such as semi-shaded valleys where *Cyathea* fern trees are often numerous (Kingdon, 1982). It is also crepuscular and has both diurnal and nocturnal activity periods.

For species that were not seen at all, yet known to occur in the park, one of the explanations is that the road did not traverse their preferred habitats. For example, bushpigs prefer places where there is sufficient moisture to support dense vegetation throughout the year and to keep the ground moderately soft. For others, nonuse of the bamboo zone is puzzling. Chimpanzees are for instance known to live in a wide range of altitudes, up to 2750 m, and mountain gorillas in the Virunga-Volcanoes are known to range in bamboo zones where they feed on bamboo during wet months when the bamboo put up new shoots. It is likely that observations of those species were also influenced by the road. For example, unhabituated gorilla groups are known to be shy of human-disturbed areas and likely avoid roads (Goldsmith, Glick & Ngabirano, 2006) and especially the sound of approaching vehicles.

Many other rainforest animals are also known to be affected by roads (Goosem, 1997; Laurance, Stouffer & Laurance, 2004). No road kills were observed during this study. Traffic disturbances and edge effects are known to increase the avoidance of road edge habitat by some species, and species that avoid open spaces are unlikely to be seen by the roadsides, while those that do not avoid open space are likely to be seen (Goosem, 1997).

Where hunters use roads to access hunting sites, roads may have a depressing effect on hunted species. For example in Gabon, roads depressed abundance of duikers, sitatungas, and forest elephants (Laurance *et al.*, 2006). We did not have data to illustrate the effect of activity along the roads on the probability of animals being sighted. We do however think that for species that were not seen, habitat selection, temporal habits, and road traffic but not hunting are likely explanations of their absence as hunters in several Ugandan sites typically do not use roads to access hunting sites (as mentioned to W. Olupot during his interviews with surrendered hunters associated with major hunting sites in the country (Olupot, McNeilage & Plumptre, 2009). Reduced human traffic along this road section could increase the number of species and numbers of individuals seen and therefore makes this area more attractive for tourism.

The cost of the methods of this study was very low. Little additional effort and cost were required beyond setting up distance markers. We believe such methods could be used in future in many locations where professional research and monitoring staff might be unaffordable. Although there are strong indications – for example as seen with francolins – that habitat use patterns observed reflect the reality for many of the species including those known to occur in Bwindi but not observed in this study, reliability for species other than francolins needs to be verified using independent, potentially high-cost methods. If they can be considered reliable, such data might, over time, help to build up a much clearer picture of many of the species encountered. For continued monitoring at this site, similar low-cost procedures should be followed.

Conclusions

The consistent and meaningful degree of nonrandomness of spatial and temporal patterns in the road observation data shows the potential of this method to serve as a low-cost assessment approach. Our data, though limited, are sufficient to demonstrate the potential of road-based

observations for monitoring population changes or inferring the response of individual species to roads. From a tourist value perspective, the data point to what species visitors to this part of the park can expect to see, and the times of day and year in which they can be best seen.

Common sense options are needed for improved conservation practice. When resources are limited, the relative value of all potential activities must be assessed in terms of their relevance to achieving basic conservation goals (Sheil, 2001). Road monitoring is not only a common sense option but a low-cost one at that for the section of the park through which this road runs. While no major population trends were anticipated or observed during the 3 years of this study, gathering road-based data provided one simple means to detect changes in the species of conservation interest over time.

Acknowledgements

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