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Activity of Forest Elephant (*Loxodonta cyclotis*) In Two Clearings within Ogooué Leketi National Park, Congo Brazzaville

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Abstract

In order to increase our understanding of forest elephant (*Loxodonta cyclotis*) vocal communication, this study examined the spatial and temporal activity of elephants from two forest clearings (Bissoloko and Madjouama). To obtain data on the visit of elephant in the clearings daily, it requires considerable human and financial resources for conservation programs observations. However, we deployed autonomous acoustic recorders "SM2" to assess elephants' activities both day and night time from 2013 to 2014. Elephant visitation in these clearings depends on certain factors as, seasons, years, and preferences of elephant to use one or more site. As a results this study found that (i) elephants visited Bissoloko clearing more than Madjouama, although these two clearings were within 5 km distant one another; (ii) Eighty six per cent of elephant calls occurred at night, and large changes in call density at night often were not reflected in similar changes during the day; (iii) there were significant differences in the calls made at night; (iv) elephants were found to be visiting clearings more often in the wet season than in the dry season; (v) visitation was significantly higher in 2013 than in 2014. Elephants used randomly one or other clearings. This empirical study suggests that African forest elephant has two vocal communication practices. Spatially separated females engage in rumble exchanges that help them to coordinate their movements and to bring them together. Both male and female elephants produce "mate attraction" rumbles to inform the opposite sex of their reproductive status. These results show the value of acoustic monitoring as a tool for better understanding of forest elephant behaviour. We suggest that passive acoustic monitoring should be incorporated into forest elephant monitoring programs to complement direct observations at forest clearings.
Keywords: Acoustic monitoring; Forest elephant; Conservation; Vocal communication.

1. Introduction

The acoustic repertoire of African savannah elephants (*Loxodonta africana*) has been extensively studied [1-3], but less is known about the structure and social context of the vocalisations of the African forest elephant (*Loxodonta cyclotis*) [4]. To keep the cohesion of groups, both species of elephants communicate between themselves using 'short-medium' [2] as well as 'long distance' [5] acoustic signals. Berg and his colleagues identified a total of 31 different types of call made by savannah elephants [6]. Forest elephants produce the same type of calls but have been classified into four main categories as trumpet, roars, rumble and Aoogas 'combinatorial calls' (roars and rumbles in different combinations) [7]. Berg [6] found that high frequency (322-570 Hz) and low-frequency (18-28 Hz) vocalisations each constituted nearly 50 per cent of the recorded vocalisations. Identifying the low-frequency vocalisation was a challenging task according to Payne, *et al.* [5] because it was difficult for humans to hear and localise it with individual callers. Berg [6], suggested that low-frequency vocalisations occurred during low levels of excitement and may function to reinforce group cohesion and coordinate social dynamics. Other studies examining low-frequency vocalisations have shown that these calls contained infrasonic components that had the potential to transmit information over very long distances covering 2.5 km to as much as 10 km [1-3]. All species of elephants live in highly organised matriarchal headed social units [8-10]. These stable family units interact with

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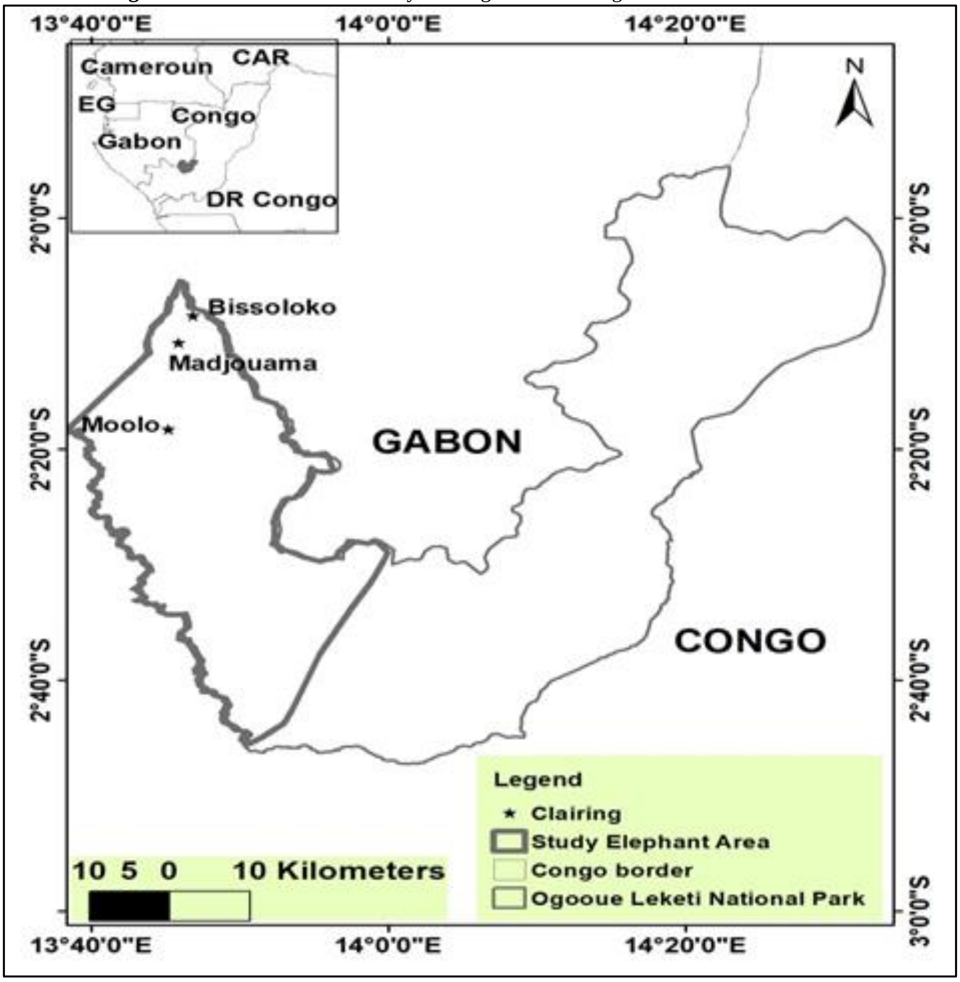
other groups of elephants to varying degrees depending on ecological conditions [3, 11, 12]. From all form of intraspecific interactions, forest elephants use the most low frequency vocalisation called "rumbles", to maintain long distance social coordination in the contexts of group and individual avoidance. Females having offsprings call more often to keep family member in cohesion whereas male in musth call less often [5, 13]. Low-frequency sounds propagate through the atmosphere and the ground more efficiently than high-frequency sounds and therefore the low-frequency rumbles of elephants can be used in long distance communication [2, 3, 5]. Most of our understanding of forest elephant social behaviour and group size comes from studies conducted at forest clearings (also called bais) in which elephants congregate to obtain scarce minerals [14, 15] and interact socially [11, 16, 17]. Forest clearings are of critical importance in the ecology of many forest elephant populations, as evidenced by the dense network of trails surrounding them [14, 18, 19] and by sustained elephant activity despite high poaching risk [20]. Direct observation of elephants at clearings serves at least two purposes, first, to obtain demographic data that are also useful for evaluating the health of elephant populations. Second, to provide a human presence that is thought to dissuade poaching. However, visual studies focus almost entirely on only part of the daytime period in spite of studies showing that elephants are more likely to frequent clearings at night [20-22]. Here, we present the results from a study using autonomous acoustic monitoring to study spatial and temporal variation in forest elephant activity at two forest clearings in Congo.

2. Material and Methods

The study was carried out in two forest clearings called Madjouama and Bissoloko, now within the Ogooué Leketi National Park (4230 km^2) in the southwest of the Republic of Congo (Fig.1).

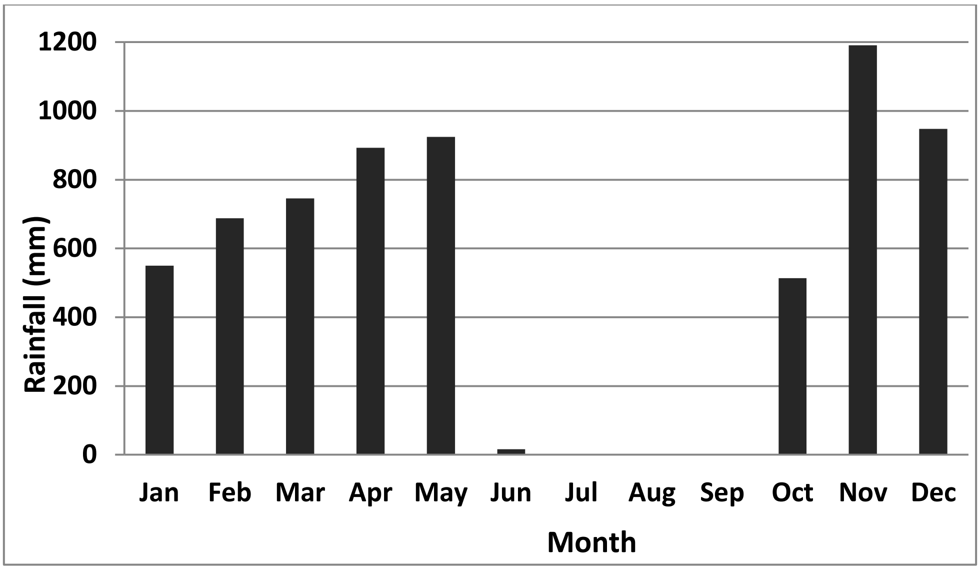
The research reported here was part of the Ogooué Leketi Elephant Project (OLEP), an 11 year study of elephant and human activity on the Batéké Plateaux.

Figure-1. Location of the two study clearings within the Ogooué-Leketi National Park



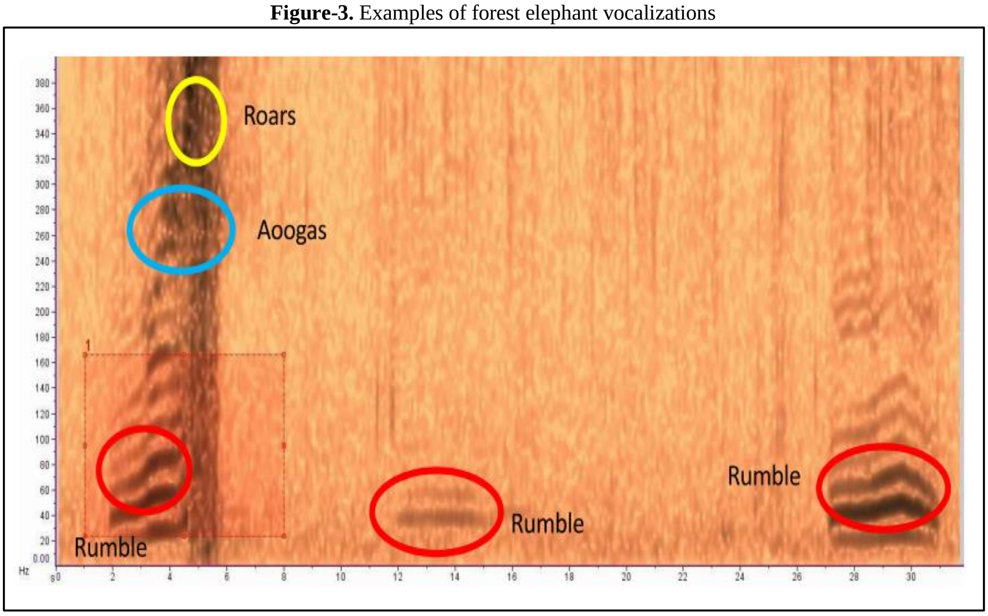
This study area is one component of the Leconi Batéké Lefini Landscape, characterized by a tropical transitional climate [23]. According to all country, the subequatorial climate type is in the north and the climate of type bas Congolese in the south. The rainy data presented below are from a meteorological station called Mining Project Development (MPD) which is in the buffer zone of the study area. The rainy regime (Fig. 2) is characterized as listed one dry season from June to September with almost 60 mm of rainfall. The remaining months from October to May is reserved for rainy season with the peak observed in November with more than 1000 mm of rainfall.

Figure-2. Mean Rainfall per month, 2013-2015, recorded at the Mining Project Development station



ACOUSTIC MONITORING and Direct observation: Elephant calls were recorded using an SM2 autonomous recorder (Wildlife Acoustics, Concord, MA, USA), suspended 7-10 m high in a tree at the edge of the clearing. This location was to minimize the damage occurring from the large mammals and to keep them concealed from the eyes of humans. The distance from the centre of clearing to recorders was less than 40 m. The SM2 can record an elephant vocalisation at a distance of about 800 m (thus covering 2 km^2 area); therefore not all calls recorded were from elephants in the open clearing area. We assume that all elephants within recording distance were present to visit the clearing. Recordings were continuous for as long as the power supply lasted (up to three months) and stored on internal SD cards. Each month of recording at each site results in about 20GB of sound data. Locating elephant calls in this sound stream is prohibitively time consuming, so we used an automatic detector algorithm [24] that, on average, successfully tagged 80% of elephant rumbles recorded (range 0.75–0.94, depending on site). Detector output was verified visually to omit non-elephant signals using criteria adapted by Clement Inkamba-Nkulu from standards developed at Cornell University. Visualisation was accomplished using Raven Pro sound analysis software (©Center for Conservation Bioacoustics, Cornell Lab of Ornithology). Elephant rumble vocalizations are typically distinct, particularly when recorded from relatively close distances, and primary energy falls between 10 and 500 Hz (Fig. 3).

Figure-3. Examples of forest elephant vocalizations



Visual observation: Forest elephants were monitored at the Madjouama and Bissiloko clearings for a total of 307 days between January 2013 and December 2014 (Table 1). We examined in theory a period of 15 days for each of the two seasons at each clearing (so 60 days per clearing per year). At these two clearings, Bissoloko and Madjouama (only five kilometers apart), in which observations were made on alternate days. Observations were conducted between 12:00 h and 17:30 h because the majority of elephant visits were occurring late afternoon and night. In a few instances observations were expanded so that all hours of daylight between 06:00 h to 17:45 h. Observations were made from a wooden platform about 8 meters height located downwind at the edge of each clearing. We used a spotting scope and binoculars to observe elephants, and a camera was used to take images of individuals for subsequent identification. Identification was based on morphological characteristics such as ear shape, notches and rips, tusk length and shape, among others [15, 17, 25]. Ages were classed as 'adult', 'sub adult', 'juvenile', and 'infant' based on the height of the individual. The 'Adult' class was defined by estimation of the tusk length and body size. 'Sub-adults' were between adult and immature animals, tusk formation aided in age determination. 'Juveniles' were defined as between 2 and 10 years old and 'Infants' as less than 2 years of age. Sampling effort based on acoustic recording or by direct observation was not uniform across the study period or at the two bais or clearings (Table 1). Gaps in data collection occurred for diverse logistical reasons, in the case of acoustic monitoring because of limited power and/or equipment failure, in the case of human observation lack of human resources, poaching activity made it unsafe, etc.

Table-1. Sampling frequency for both acoustic and human observation at the study sites (Dry season months indicated by shading)

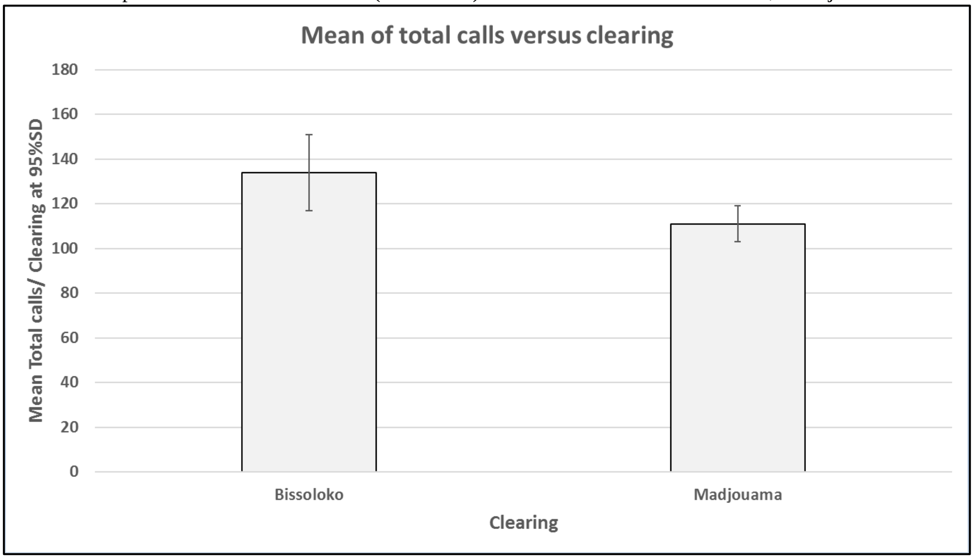
Month	Bissoloko				Madjouama			
	Days acoustic		Days human		Days acoustic		Days human	
	2013	2014	2013	2014	2013	2014	2013	2014
Jan	0	11	1	0	31	31	2	0
Feb	0	9	7	6	27	28	7	14
Mar	0	9	4	0	25	31	11	8
Apr	0	9	8	0	30	22	11	0
May	21	0	14	0	25	0	15	0
Jun	0	0	9	0	18	0	26	0
Jul	20	15	17	0	30	15	14	0
Aug	0	11	4	7	11	24	6	6
Sep	11	2	7	3	12	30	8	0
Oct	31	0	9	0	31	23	20	0
Nov	23	0	4	0	30	0	9	0
Dec	0	10	0	2	31	14	0	7

Daily and Seasonal patterns: We defined an 'elephant day' as the 24-h period beginning at 06.00 h, divided into 12-h day (06.00–17.59 h) and night (18.00–05.59 h the following day) portions [21]. We defined wet and dry season periods on the basis of rainfall explained above. The periods with rainfall below 60 mm the annual mean value was considered dry season. The resulting wet and dry season periods correspond reasonably well to the 'typical' wet and dry periods in these locations, but allows for significant variation in specific study years. For statistical analysis, two software packages were used for all statistical analysis especially SPSS (version 16.0, SPSS, Inc.) and JMP SYSTAT. Chi squared test was used to compare the means of elephants calls in two clearings. Least Square Mean test was used to assume that the variables (clearing, season and year) satisfy assumptions of normality and to compare the mean of several variables and their interactions. Predictors were considered statistically significant when the probability of Type I was less than 0.05. Most of our analysis is dealing with count data. Linear regression assumes that the response variable is normally distributed although count data (Number of calls per day) are not. Count data is usually negative binomial. Before using linear regression we would need to transform the count data and model that transformed value. For binomial this is usually the square root transformation (arcsine transformation if lots of zeros, adding a small value, like 0.25 to each count before taking the square root. The transformed values were closer to normal and the residuals from the models were normal (the most important issue).

3. Results

Elephants were using the Bissoloko and Madjouama Claerings nearly in the same frequency during these two years of study (Pearson Chi-Square χ^2 = 2.594, df= 1, N=248, P = 0.296, see the Fig 4 below).

Fig-4. Mean of elephants total calls in 24 hours (2013-2014). Means Bissoloko 134±18SD; Madjouama 117±7SD.



Elephants frequented both clearings primarily at night (overall 85.77% of calls) and the pattern was almost identical in both clearings. Elephants started entering in the clearings during late afternoons, around 17:00, reached peak numbers at about 21:00 hrs and thereafter numbers declined to their lowest at 9:00-10:00 hrs (Figures 5 and 6).

Figure-5. Pattern of visitation by forest elephant into Bissoloko clearings

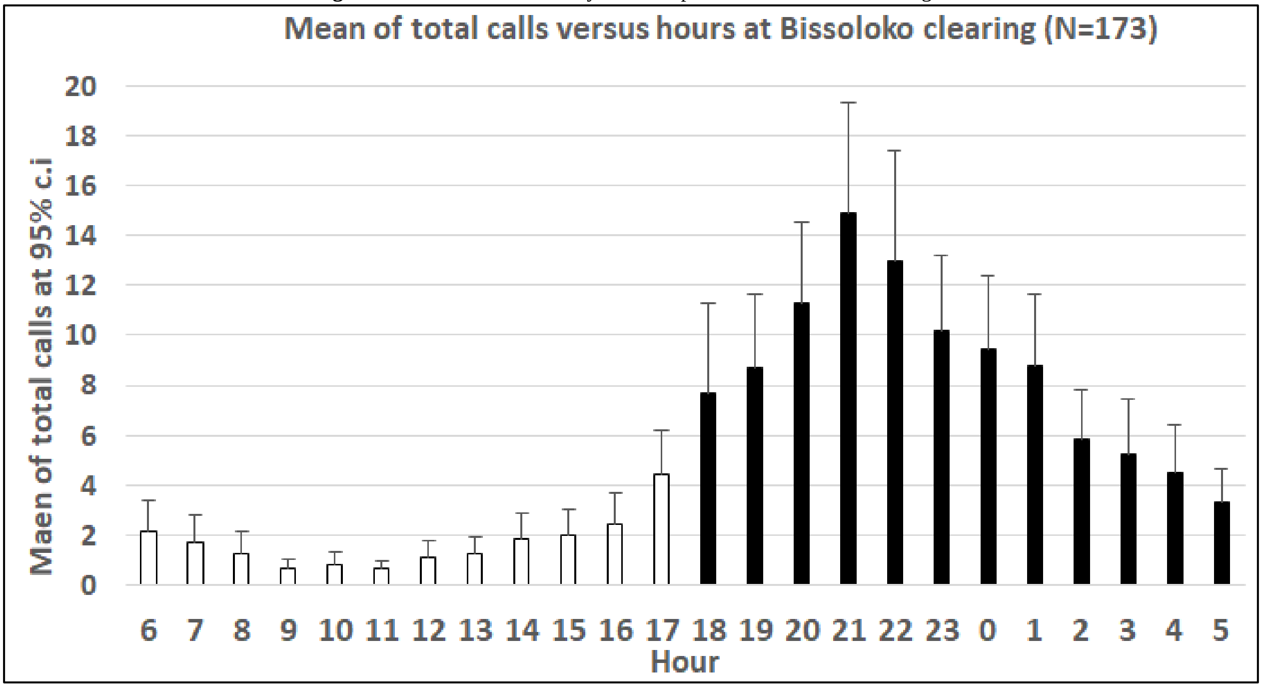
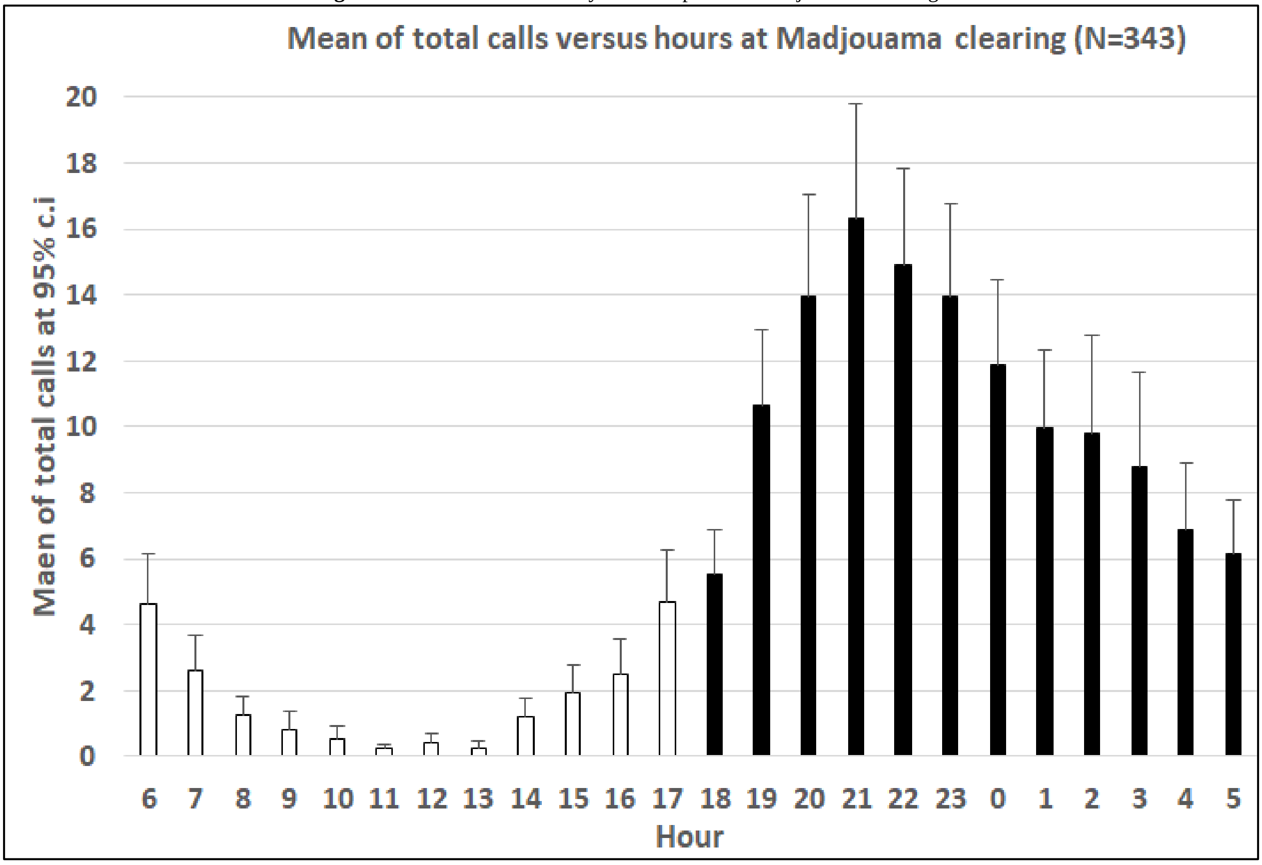


Figure-6. Pattern of visitation by forest elephant in Madjouama Clearing



Data were collected every month throughout two years 2013 and 2014 combined in two clearings with an exception of one month of June at Bissoloko. Bissoloko recorded high number of calls from 150 to 275 calls in February, May and July; the remaining months recorded less frequency from 25 to 100 calls (Fig.7). However, in Madjouama, the high mean of calls were recorded between January to April and November to December (about 100-200 calls). Fewer means in a range of 10 to 90 calls were recorded in the remaining months (Fig. 8).

Figure-7. Mean of total calls by month in Bissoloko

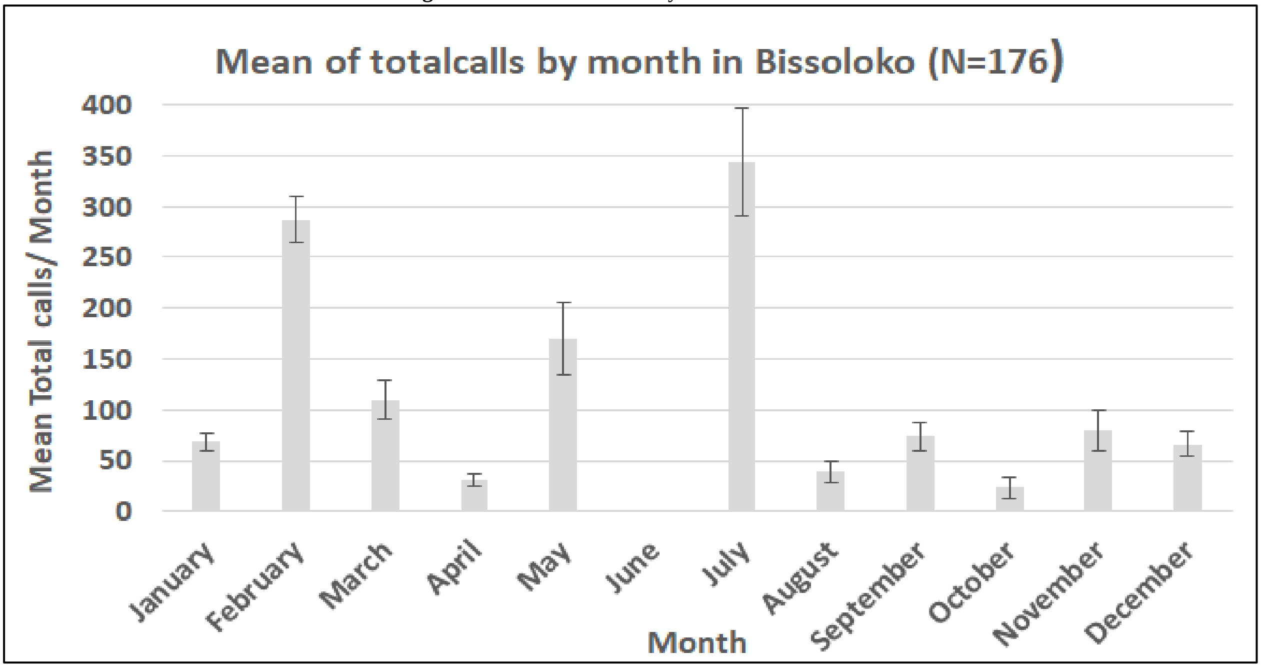
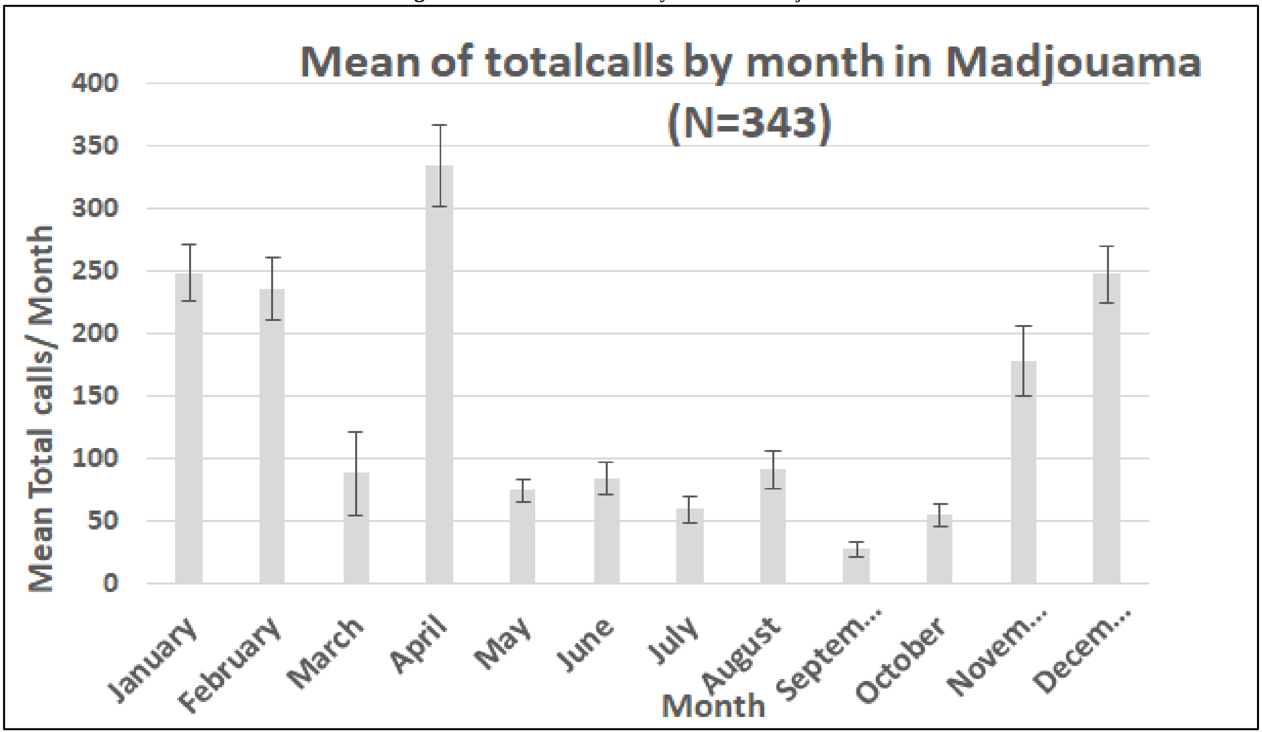


Figure-8. Mean of total calls by month in Madjouama



To determine the important ecological and climactic factors which attract elephants to the clearings, a Least Square Mean test was used to assume that variables satisfy assumptions of binomial and to compare the mean of several variables and their interactions. For this, three variables were taken into account viz., clearing, year, season and theirs interactions. Table 2 shows that clearing considering alone has no impact on elephant's visitation (P>0.7005) meanwhile year, season and interaction of all these three variables are highly significant (P<0.05).

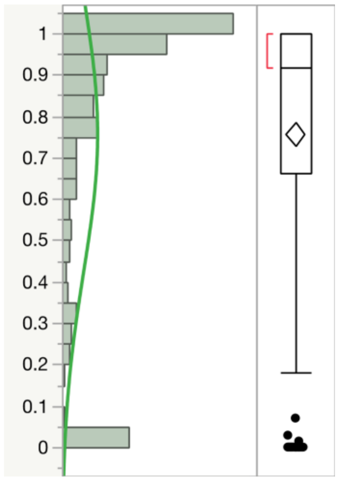
Table-2. Parameter Estimates in elephants calls in clearing

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	107.5	8.87	12.12	<.0001*
Clearing [biss]	3.414	8.87	0.38	0.7005
Year[2013]	25.74	8.87	2.90	0.0038*
Season [dry]	23.64	8.87	2.66	0.0079*
Bai [biss]*year[2013]	19.73	8.87	2.22	0.0265*
Bai [biss]*season[dry]	-33.03	8.87	-3.72	0.0002*
Year [2013]*season[dry]	-29.81	8.87	-3.36	0.0008*
Bai [biss]*year[2013]*season[dry]	-25.78	8.87	-2.91	0.0038*

Linear regression goodness of fit tests are significant when there is evidence for LACK OF FIT.Visitation of elephants in one or another clearings shows a normal distribution (P<0.0001) (Fig.9), after transforming data by arcsine this one confirm that elephants as nocturnal activities (P<0.0001) (Fig.10).

Figure-9. Nite percentage normal distribution

Percent Nite (pctnite), showing fit of a normal distribution (green)

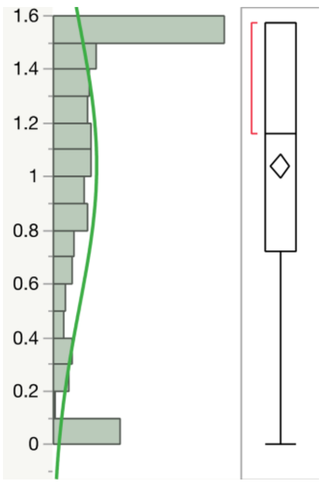


Goodness-of-Fit Test

	W	Prob<W
Shapiro-Wilk	0.72516 87	<.0001*

Figure-10. Arcsine transformation normal distribution
A2 Prob > A2

Arcsine Transform of percent nite, showing fit of a normal distribution (green)



Compared to the pure percent nite, this is a little bit better, but still way too many at the highest value.

Goodness-of-Fit Test

	W	Prob<W
Shapiro-Wilk	0.857278	<.0001*

	A2	Prob > A2
Anderson-Darling	23.104684	<.0001*

Elephants have visited more clearing in 2013 than in 2014 at Bissoloko but the visitation was almost standard at Madjouama. Elephants visited more clearing during the rainy season than dry season at Madjouama whereas Bissoloko had less preference for season ($p<0.0079$, Table 2). Elephants were more frequent at wet season in 2014 and less frequent during the dry season; visitation of elephants in 2013 was almost standard without preference of season. Interaction of clearing, year and season show that elephants use clearing more in dry season than rainy seasons during the study periods (2013-2014).

4. Discussion

There are a limited number of well-known long-term forest elephant studies by direct observation in Congo basin [16, 26, 27]. Above all, Dzanga is the longest bai monitoring study followed by Mbeli bai on African forest elephants frequenting clearings throughout the Congo basin area. The present study contributes to one of the study sites in which forest elephants were monitored in Congo from two clearings (Bissoloko and Madjouama). This last study adds information resulted out of monitoring both day and night visitation from acoustic sound and direct observation. Bissoloko clearing shows a numerous elephants' calls than Madjouama clearing (Figure 4). This high attraction of elephants to Bissoloko clearing is assumed to be due to its large area with more than 40 waterholes in which elephants drink the salty water compared to Madjouama clearing which has around less 20 waterholes. However, there is no significant difference in the visitation of elephants in these two Clearings. These two clearings show the same pattern of elephants' visitation daily which is equal to the time spent on activities. Elephants visited clearings more during late afternoons, the number increase at night when they felt more relax and they left the clearings early mornings as shown in the figures 5 and 6. This study agrees with the observations of Turkalo and Fay [17], and Momont [26], who had emphasised that forest elephant visitation at clearings, was highly variable on both short (hourly, daily) and moderate (seasonal) timescales. There is little reliability among the long-term study sites with respect to wet–dry season effects on elephant visitation behaviour, even for those sites sharing similar rainfall patterns [16, 17, 26, 28]. Our acoustic data show relatively that high numbers of calls occurred multiple times throughout the year at all sites. Presently, not enough is known about variation in forest elephant nutritional intake, nutrient demands and timing of reproduction to speculate on how these factors might influence clearing visitation. A number of studies indicate that forest elephants prefer to enter forest clearings at night [20, 26, 28-32] although in all cases, sample sizes were small and often observations were limited to nights of the full moon. Besides of this, [22] have published better data than any of these on proportion of night activity. The acoustic data presented here confirm these previous findings with consistent sampling at two locations. Most of daily elephants' calls arrived at night (85.77 per cent) and fewer calls were registered during the day time (14.23 per cent). This bias towards nocturnal use of clearings is noticeably different from nearly equal day and night activity shown by forest elephants when in the forest [22, 33]. Several studies have observed a shift to nocturnal behaviour by elephants when exposed to disturbances created by human [33-36] and elephants avoid forest clearings during the day when poachers are around [20, 37, 38]. Two findings from our study are particularly important from the conservation perspective.

First, we found that the number of elephants frequenting a clearing cannot be estimated from daytime-only observation. Although there is a significant difference of calls between day and night time, the relative proportion of day versus night visitation was not consistent, even within a site (Table 2). Least Square Mean test which assumes that the variables satisfy assumptions normality and to compare the mean of several variables and their interactions shows that elephant visitation was not dependent on the site structure but influenced by seasons and year. Meanwhile, interaction of clearing, seasons and year factors make clearings a dependent variable (Table 2). Since, availability of fruits become rare throughout the forest during the dry seasons, elephants have to feed mostly on leaves of such plant species that are toxic [30]. However, the elephants' need in one hand to eat more clay to detoxify plant compounds and in other hand to drink minerals water from the clearings to compensate for low minerals in their diet. Acoustic monitoring provides continuous data that can be regularly collected at all times of day, all seasons and without human bias or influence, despite of the visibility of the elephants. This useful acoustic tool could not replace human to observe wildlife in clearings but can be combined with that on daytime visual observation and helps in identifying potential population structure and the health of animals. Once the basic skills of acoustic analysis have been obtained by field personnel, acoustic monitoring offers an efficient and cost effective conservation tool for monitoring multiple sites continuously for long time.

5. Conclusion and Suggestions

To sum up, this monitoring study commenced from 2013 to 2014 in two clearings using an acoustic set found that:

- Forest elephants are visiting more Bissoloko clearing which has more salt waterholes than Madjouama clearing which has less waterholes;
- Elephants were found visiting the clearing mostly during the night time (86 per cent) than during the day time (14 per cent) suggesting a trend of individuals spending their day time for eating fruits and leave in forest. Since, night time is cooler, elephants feel more relaxed, hence go to clearings.
- Climatic and ecological factors have an influence on the elephants' behaviour. Elephants make more calls in the clearings during the wet season and, this behaviour depends on the year and the interaction of these three variables. Structure of clearing alone is not significant.

Acoustic set is a useful tool that helps in managing a long term monitoring that is required and compliment human observations to stop poaching menace.

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