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Full Length Research Paper

Vegetation studies of Non-Timber Forest Products (NTFPs) at three sites with varying levels of anthropogenic disturbances in the Southern Bakundu Forest Reserve, Cameroon

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A study was carried out to evaluate the distribution, abundance and diversity of Non-Timber Forest Products (NTFPs) in the Southern Bakundu Forest Reserve at the northern (Diffa), western (Bai Manya) and eastern (Mbalangi) parts of the reserve. NTFPs can be used as source of food, medicine, fuel wood and other socio-economic and cultural uses. Six belt-transects were use at each site to assess the distribution, abundance and diversity of NTFPs in this Forest Reserve. The southern part of the reserve was not evaluated as it was heavily encroached with cocoa plantations. A total of 50 species in 40 genera and 27 families were identified. 28 species were most commonly distributed in the three sites. These include *Irvingia gabonensis*, *Trichoscypha abut* and *Cola lepidota*, while *Garcinia cola*, *Baillonella toxisperma* and *Tetracarpidium conophorum*, *Raphia* species and *Afromomum citratum* were restricted to one or two sites. The northern part of the forest had the highest number of useful plants (3119), followed by the eastern part (837) and lastly by the western part (774). Between sites, Bai Manya and Diffa were most similar (Jaccard Index = 0.65; Sorenson Coefficient = 0.79). The western part had the highest species diversity (D = 0.92), followed by the northern part (D = 0.85) and lastly by the eastern part (D = 0.8).The results are significant for better management and conservation of this forest reserve.

Key words: Non-timber Forest Products (NTFPs), species diversity, similarity indices, abundance, frequency, anthropogenic.

INTRODUCTION

The Southern Bakundu Forest Reserve (SBFR) was established in about 1939 by the British Colonial Authorities, mainly for selective exploitation of timber for domestic construction and export. In 1959, the reserve

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was passed on to the Cameroon Ministry of Forestry which initiated regeneration activities in a 160 ha compartment. In 1972, the “Fond Nationale de Development Forestiere et Piscicole” established an additional 312 ha. Human habitats surrounding the forest increased tremendously with time, resulting in encroachment into the forest for slash and burn agriculture and also harvest of Non-timber Forest Products (NTFPs) on which the local populations depend heavily for food, fuel wood, medicine and condiments (Banjade and Paudel, 2008; Focho et al., 2009; Hossanet al., 2010; Jiofac et al., 2009; Simbo, 2010; Egbe et al., 2012; Nang and Dioggban, 2015). The resulting decrease in forest area and quality negatively alters ecosystem functioning and services (Aerts and Honnay, 2011). In 1982, the “Office Nationale de Regeneration Forestiére” (ONADEF) countered this encroachment by establishing 258 more hectares. However, harvests of NTFPs and illegal logging in the forest reserve continued unabated, resulting in massive degradation of the forest. It became apparent that effective conservation has to take into consideration the needs of the forest users. It has been shown that forest management and rehabilitation depend greatly on the resources that are found in the forest and the strategic role the forest plays to the surrounding population and environment (Sunderland et al., 1999; Jewitt et al., 2014). In the SBFR, exploitation of NTFP which constitutes an important activity thus has to be considered alongside mainstream management of the reserve. Non-timber forest products have been shown to serve a dual role as a “possible” tool for the conservation of tropical forest through community participatory approach and as an economic cornerstone (Incentive Approach Theory) for the local population (Peters et al., 1989; Wong, 2000b). However, unchecked harvesting erodes biomass and degrades the forest, with the potential to influence species retention, abundance and diversity (Hughes, 2012). Efforts by the government, NGOs and donors to protect the SBFR and promote sustainable harvesting of the NTFPs from forest reserves have not been successful, as the level of deforestation and degradation of this forest and its NTFPs (e.g. depletion of *Gnetum africanum* Welw.stock) continue unabated. According to the Intermediate Disturbance Hypothesis, maximum species richness should be expected at sites with an intermediate level of disturbance (Bongers et al., 2009; Hughes, 2012). Thus, NTFPs harvesting and other ‘necessary’ disturbances should aim at not exploiting beyond this optimum level. Without dedicated studies however, it is unclear whether or not the present levels of exploitation and other anthropogenic disturbances in the SBFR are sustainable, and the effects on flora biodiversity are unknown. In addition, no studies of pristine conditions at this site exist for comparison. Thus, despite the high value of some of the NTFPs in and around the Southern Bakundu Forest Reserve (SBFR) and coupled with the high rates of exploitation, agricultural expansion, increased urbanisation and general deforestation of this important catchment over the past 33 years (Oyono et al., 1997) there is no available literature on the associated dynamics of NTFP species distribution, abundance and diversity at the different sites.

While studies on NTFPs mainly focuses on ethnobotany and domestication in Cameroon exist for *Irvingia* species, *Ricinodendron heudelotii* (Baill) Pierre ex Pax & Hoffm, *Prunus africanab* (Hook.f.) Kalkmanetc, with export potentials (Ayuk et al., 1999; Malleson, 2000; Awono et al., 2002; Ndoye, 2005; Focho et al., 2010; Egbe et al., 2012), research has mainly ignored studies on diversity and population structure of these species, which are key to the understanding of long-term species retention, and the general health of the forest. In Cameroon, there is very good legislation on forest management but the major constraint is its effective implementation in the field. Recent information indicates that the Cameroon Government is in the process of transferring the management of this forest reserve to the local communities, and so a baseline study of diversity and abundance of NTFPs is essential to understand the present dynamics and comparisons with future studies. The aim of this study was to identify NTFPs and evaluate their diversity and abundance across sites in the SBFR. This work goes a long way in contributing to the baseline data bank of NTFPs in the SBFR, which is needed for the rehabilitation of this forest.

MATERIALS AND METHODS

The study area

This study was carried out in the Southern Bakundu Forest Reserve (SBFR). This reserve is found in Mbonge Subdivision, Meme Division, Southwestern Cameroon (Figure 1). The SBFR is located in the belt of the Gulf of Guinea (Biafra), between latitudes 4°20′ and 4°50′ north of the equator, 9°0′ and 9°30′ east and north of Mount Cameroon (Mekou, 2003). The forest covers an area of 18100 ha and is surrounded by 22 villages. It is bounded to the north by the Kumba-Mbonge road, to the south by the Cameroon Development Cooperation CDC rubber and palm plantations, to the east by the Kumba-Buea road and to the west by the Kumba metropolis.

The climate is humid and tropical, characterized by a long rainy season from March to October and the short dry season from November to January. The mean annual rainfall and temperature of the SBFR are 2200 mm and 29.01°C, respectively. The average relative humidity is constantly higher than 86%, with an average sunshine period of about 260 days. The climate does not vary greatly between villages around the forest. Two major soil types are found in the Sothern Bakundu Forest Area (SBFA); the deep well drained yellowish brown sandy clay soils developed from old sedimentary deposits and the deep brown clay soils developed from volcanic materials (Ngole, 2005). The topography is irregular, with flats and gentle slopes of between 5 and 8%, although slopes of more than 25% can be seen near waterfalls (Ngole, 2005). An

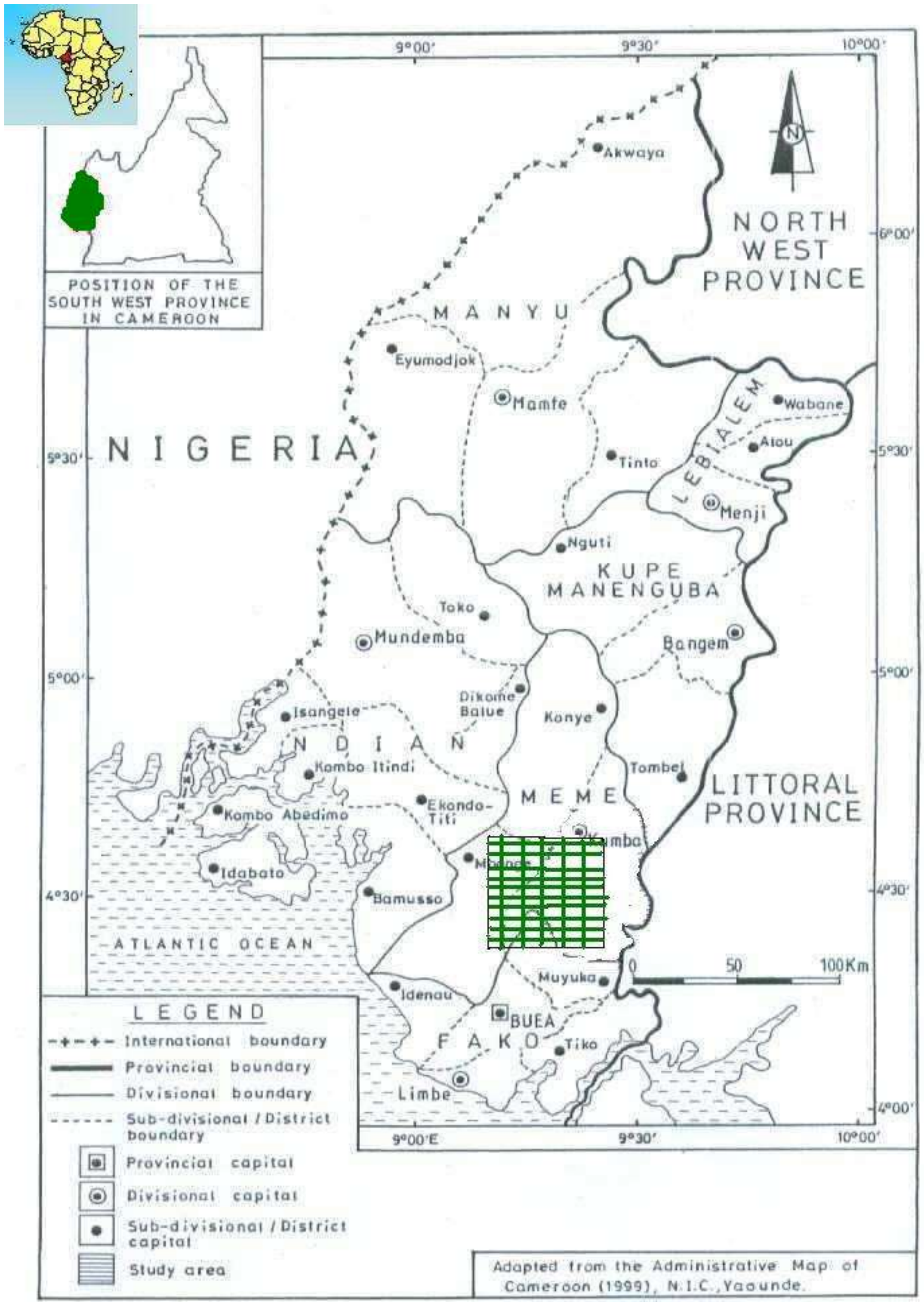

Figure 1. Map of the South West Region showing the location of the study site.

average altitude of about 200 m dominates the forest, with the lowest of about 30 m found in the southwestern part and the

Table 1. Vegetation classification of the Southern Bakundu Forest Reserve.

Type of forest	Area covered (ha)	Percentage
Primary forest	7052	39
Secondary young forest	936	5.17
Secondary old forest	9160	50.6
Plantation and agroforestry	952	5.27
Total	18100	100

This classification has changed drastically ever since, as more farms have been established in the area.
Source: Southern Bakundu Project (1994).

Table 2. Location of study sites.

Village	Approximate distance from village (km)	Geographical orientation
Mbalangi	12	East
Diffa	7-8.5	North
Bai Manya	15	West
Muyenge, Mussone, Lykoko	>20*	South (Intensive encroachment into the reserve land)

*Heavily degraded areas in the southern villages.

highest of 300 m, occurring on hills of the western parts of the forest (Ngole, 2005).

The vegetation is dense evergreen tropical rainforest. This reserve is classed mainly in the lowland range (0 to 800 m), within the Biafrean Atlantic district, dominated by mainly the Caesalpinaceae (Mekou, 2003). The lowland rainforest in which the SBFR is found accounts for the most important vegetation type with very high species diversity (Mekou, 2003). The Southern Bakundu Project classified the vegetation of the SBFR into four major forest types: primary, secondary old forest, secondary young forest, plantation and Agroforestry (Table 1). These area cover and forest type are not what is obtain today as there have been a lot of encroachments after 1994.

Ecological survey

A reconnaissance survey was carried out to select study sites and sampling points in the field. Four villages surrounding the SBFR, representing the cardinal coordinates were chosen and six transects per village were selected for more detailed study. One village was selected each to represent the north, south, east and west of the reserve, respectively (Table 2). This was aimed at reducing bias and improving on full coverage of the reserve.

Sampling design

Baselines were chosen in the reserve at about 100 m from the limits of encroachment into the forest reserve. This was to reduce the influence of direct and visible human activities on the results. Sampling was based on the methods of Hall and Bawa (1993). Six belt transects of 500 ×10 m were set up at each site. These transects were set up in parallel series separated by 200 m gaps. This was to ensure that the presence or absence of a targeted species in one transect does not influenice the probability of the species occurring in any other transect (Wong, 2000a). Each transects was evaluated as a replicate to reduce the sampling error margin (Wong, 2000a). Quadrats of 20 × 10 m were randomly created in each transect to sample smaller NTFPs such as *Gnetum* species. Sampling was done within each transect, with a researcher on either side of each transect carefully searching for, and recording the NTFP species (Peters, 1994, 1996). Parameters recorded included presence/absence, abundance, and some NTFPs were only counted e.g. rattans, *Gnetum* (in the 20 × 10 m quadrats), while others such as *Afromomum* and *Thaumatococus* species were counted by stands.

Voucher specimens were collected in cases where species could not be well identified; these were tagged, oven-dried and identified post-collection at the Limbe Botanic Garden Herbarium (SCA).

Data analyses

Species diversity and similarity between sites

Simpson diversity index, Jaccard's coefficient and Sorenson similarity index were calculated for the different sites, according to the equations outlined:

$$\textit{Simpson Index } \lambda = \sum_{i=1}^{R} pi2 \qquad (1)$$

where pi = proportional abundance of the ith species, R = maximum number of species.

Similarity indices were calculated using Jaccard's and Sorensen's coefficients:

$$\textit{Jaccard's Coefficient} = \frac{|\,Q \cap D|}{|\,Q \cup D|} = \frac{p}{p+q+d} \qquad (2)$$

where p = number of species present in both sites; q = number of species present in Q but not in D; d = number of species present in D but not in Q.

$$Sorensen's\ Coefficient\ Cn = \frac{2c}{a+b} \quad (3)$$

where Cn = Sorensen similarity coefficient; c = number of species common to samples A and sample B; b = number of species in sample B, and a = number of species in sample A.

Frequency and abundance of species within the different sites

The frequency of occurrence of each species was calculated for the different sites using the formula:

$$Frequency = \frac{Y}{Z} * 100 \quad (4)$$

where Y = Number of transects in which species is present; Z = total number of transects in each site.

In terms of presence or absence of species, the evaluation of each species in each site was conducted using the Braun-Blanquet Rating scheme, plant cover rating as follows:

(1) Species present in 75-100% transect, meant that the species was highly abundant.
(2) Species present in 50-74% transect, meant that the species was moderately abundant.
(3) Species present in 25-49% transect, meant that the species was sparsely abundant.
(4) Species present in <25% transect, meant that the species was rare.

These results were further refined through Simple Correspondence Analyses of species incidence and abundance across sites, respectively. These analyses were carried out in the Minitab Version 16 statistical package (Minitab Inc., USA).

RESULTS

Distribution and abundance of NTFP species found

The 24 transects sampled from the four sites, results from the southern site were not evaluated due to intensive encroachment. Fifty NTFP species in 40 genera and 27 families were identified (Table 3). From these, 28 species most frequent are presented in Table 4. The distribution of the different NTFPs was assessed in terms of presence or absence of species at the different sites. Species such as *Irvingia gabonensis* Baill. Ex Lanen, *Trichoscypha abut* Engl & Brehmer, *Cola lepidota* K.Schum, etc., were present in all the sites while *Garcinia kola* Heckel, *Baillonella toxisperma* Pierre, and *Tetracarpidium conophorum* (Müll.Arg.) Hutch. & Dalziel were restricted to either one or two sites. Correspondence analyses showed that the observed species distribution can be explained by two main components; analysis of the contingency table indicated that Components 1 and 2 contributed 53.2 and 46.7%, respectively of the total inertia (Table 5). The two components effectively explain the distribution of species across all sites (Qual = 1). Component 1 best explains distribution of species at the North site (Diffa) (Corr = 0.95). Diffa was highly associated with *G. kola, T. conophorum*, and *Omphalocarpum procerum* P. Beauv. not found in the other sites. The west site (Bai Manya) and the east site (Mbalangi) are best explained by Component 2 (Corr = 0.836 and 0.543, respectively) (Table 5). *Nephthytis poissonii* and *B. toxisperma* were only found in Bai Manya, distinguishing it from Mbalangi where no species existed exclusively; the rest of species observed were cosmopolitan across sites (Figure 2). The detailed frequencies of the different species are presented in Table 4. *Coula edulis* Baill., *C. lepidota*, and *G. africanum* were present in all the sites (100%). Raphia palm (*Raphia* species), *G. kola* and a few other species, were rare in the wild (<25%).

Abundance

Correspondence analysis of the pattern of species abundance across sites is presented in Table 6. The first two components explained most of the spatial abundance of species, contributing 52.5 and 47.5%, respectively of the total inertia (Table 6). The two components effectively explain the spatial species abundance across all sites (Qual = 1). Component 1 explains abundance of species at the North site (Diffa) (Corr = 0.616) and Bai Manya (Corr = 0.98). *G. kola, Tetrapluera tetraptera, O. procerum, T. conophorum* and *Piper guineensis* L. have the highest abundance in Diffa, and occur at very low numbers in other sites. Similarly, *N. poissonii* (183), *B. toxisperma* (10) and *Afromomun citratum* (Pereira) K.Schum (9) have the highest abundance in Bai Manya, occurring in very low numbers across the other sites. Mbalangi was the best described by Component 2 (corr = 0.821). *Phyllanthus meullerianus* (Kuntze) Exell. has the highest abundance in Mbalangi (Table 6 and Figure 3).

Similarity and diversity indices

Bai Manya and Diffa were the most plants similar sites with Jaccard's Coefficient (C_j) of 0.65 and Sorensen's coefficient (C_n) of 0.79. Plants in Diffa and Mbalangi were the least similar sites with Jaccard's Coefficient (C_j) of 0.52 (Table 7).

Table 8 shows plant diversity indices of the different sites with respect to plant species assessed. Bai Manya was the most diverse site (D = 0.92) and Mbalangi was the least (D = 0.8) with respect to NTFPs. In terms of magnitude however all sites could be considered to be highly diverse.

Table 3. Species identified in field surveys in the SBFR.

Scientific name	Common names	Family	Habit
Afromomum citratum (Pereira) K.Schum.	Mbongo	Zingiberaceae	Herb
Afromomum sp	Alligator pepper	Zingiberaceae	Herb
Afrostyrax lepidophyllus Mildbr.	Bush onion	Styracaceae	Tree
Angylocalyx talbotii Baker	Strong cough medicine	Sterculiaceae	Tree
Arthocarpus heterophyla Lam.	Pembe	Moraceae	Tree
Baillonella toxisperma Pierre	Njambe/moabi	Sapotaceae	Tree
Canariums cheinfurthii Engl.	Bush plums/ aiele	Burseraceae	Tree
Cassia alata L.	Fish poison	Fabaceae	Shrub
Cinchona officinalis L.	Quinine plant	Rubiaceae	Tree
Cola lepidota K. Schum.	Monkey cola	Sterculiaceae	Tree
Cola nitida (Vent.) Schott &Endl.	Country kola nut	Sterculiaceae	Tree
Cola verticilata (Thonn) Stapf ex A.Chev	Two halves kola nut	Sterculiaceae	Tree
*Coula edulis*Baill	Koma	Olacaceae	Tree
Dacryodes edulis (G. Don.) H.J. Lam	Plum	Burseraceae	Tree
Dichapetalum sp	Bush water rope	Dichapetalaceae	Liana
Enantia chlorantha (Oliv)	Yellow bark	Annonaceae	Tree
Entandrophragma cylindricum (Sprague) Sprague	Sapelli	Meliaceae	Tree
Eremospatha sp	Small cane	Arecaceae	Palm
Erythrophleum ivorensis (Guill. & Perr.)	Tali	Caesalpiniaceae	Tree
Fagara sp.	Belly medicine	Rutaceae	Tree
Garcinia kola Heckel. Engl	Bitter kola	Clusiaceae	Tree
Garcinia mannii Oliv.	Chewing stick	Clusiaceae	Tree
Gnetum africana Welw.	Eru	Gnetaceae	Vine
Irvingia gabonensis (Aubry. Lecomte ex O'Rorke) *& I . wombolu*	Bush mango	Irvingiaceae	Tree
Maranthochloa holostachya (Bak.)	Mbombolo leaf	Marantaceae	Herb
Massularia acuminate (G. Don) Bullock ex Hoyle		Rubiaceae	
Megaphrynium macrostachium(Benth.) Milne-Redh	Big leafs	Marantaceae	Herb
Milicia excelsa Welw.	Iroko	Moraceae	Tree
Myrianthus arboreas (L.) Sleum.	Bush pineapple	Moraceae	Tree
Nephthytis poissonii (Engl.)N.E.Br	Mebe	Araceae	Epiphyte
Omphalocarpum procerum P. Beaux.	Dancing beads plant	Sapotaceae	Tree
Oncocalamus sp	Large cane	Arecaceae	Palm
Pentaclethra macrophylla Benth.	Botton	Fabaceae	Tree
Phyllanthus meullerianus (O.Ktze.) Exell.	White Mahum	Euphorbiaceae	Vine
Phyllanthus reticulates Poir	Red Mahum	Euphorbiaceae	Vine
Piper guineensis Schum. and Thorn	Bush pepper	Piperaceae	Vine
Pterocarpus soyauxii Taub	Camwood/Padouk	Papilionaceae	Tree
Raphia spp.	Raphia palm/ Matutu	Arecaceae	Palm
Ricinodendron heudelotii (Baill.) Pierre ex Pax &Hoffm.	Njansang	Euphorbiaceae	Tree
Sarcophrynium prionogonum (K.Schum.)	Small leaf	Marantaceae	Herb
Terapleura tetraptera (Schumach. &Thonn) Taub.	Black spice	Mimosaceae	Tree
Tetracarpidium conophorum (Mull. Arg) Hutch. & Dalziel	Africa Cashew nut	Euphorbiaceae	Vine
Tetracera alnifolia Willd.	Bush water rope	Dilleniaceae	
Thaumatococcus spp.	Fat leaf	Marantaceae	Herb
Trichoscypha abut Engl. &Brehmer	Sweet changing blood	Anacardiaceae	Tree
Trichoscypha arborea (A. Chev) A.Chev	Sour changing blood	Anacardiaceae	
Xylopia aethiopica (Dunal) A. Rich.	Achu spice	Annonaceae	Tree

Table 4. Frequency of occurrence of each species at different sites.

Species	Mbalangi			Diffa			Bai Manya		
	No. present	No. of transects out of 6 with species	Frequency (Y/Z) ×100	No. present	No. of transects out of 6 with species	Frequency (Y/Z) ×100	No. present	No. of transects out of 6 with species	Frequency (Y/Z) ×100
Irvingia gabonensis	15	5	83.3	13	6	100	16	6	100
Trichoscypha spp.	9	4	66.7	45	6	100	10	6	100
Garcinia spp.	59	6	100	62	6	100	0	0	0
Mussularia acuminata									
Coula edulis	41	6	100	18	6	100	20	6	100
Cola lepidota	28	6	100	160	6	100	37	6	100
Dacryodes edulis	0	0	0	7	4	66.7	6	3	50
R. heudelotii	0	0	0	13	6	100	12	4	66.7
Fagara spp.	11	3	50	22	2	33.3	16	5	83.3
Cinchona officinalis	0	0	0	13	4	66.7	16	5	83.3
Tetrapleura. Tetraptera	0	0	0	7	6	100	1	1	16.7
Cola grasilensis	10	4	66.7	0	0	0	16	5	83.3
Garcinia kola	0	0	0	5	2	33.3	0	0	0
Baillonella toxisperma	0	0	0	0	0	0	10	4	66.7
Omphalocarpum procerum	0	0	0	6	4	66.7	0	0	0
Gnetum africana	124	6	100	159	6	100	126	6	100
Piper guineensis	0	0	0	570	6	100	103	6	100
Oncocalamus spp.	72	6	100	147	6	100	73	6	100
Eremospatha spp.	398	6	100	1861	6	100	510	6	100
*Afromomum. Citratum (*Stands)	0	0	0	2	1	16.7	9	2	33.3
Maranthochloa spp.	2	2	33.3	3	3	50	4	2	33.3
Megaphrynium spp.	2	2	33.3	0	0	0	7	2	33.3
Thaumatococcus spp.	0	0	0	3	3	50	6	4	66.7
Sarcophrynium spp.	0	0	0	2	1	16.7	6	5	83.3
Phllanthus meullerianus	67	2	33.3	0	0	0	5	2	33.3
Tetracarpidium conophorum	0	0	0	3	2	33.3	0	0	0
Nephthytis poissonii	0	0	0	0	0	0	183	4	66.7
Raphia spp.	1	1	16.7	3	2	33.3	1	1	16.7

DISCUSSION

The aim of this study was to identify NTFPs and evaluate their distribution, diversity and abundance across sites in the SBFR. Research on species distribution, diversity and abundance patterns in forest ecosystems is essential to inform better conservation and management policy(Kanagaraj et al., 2016). This is especially true of forest ecosystems under various forms of anthropogenic disturbances. A total of 50 species in 40 genera and 27 families were observed. The patterns observed in this study are consistent with policy(Kanagaraj et al., 2016). combined effects of harvesting patterns and other anthropogenic

Table 5. Simple Correspondence Analysis of species occurrence across sites.

Axis	Analysis of the contingency table		
	Inertia	Proportion	Cumulative
1	0.1565	0.5322	0.5322
2	0.1375	0.4678	1
Total	0.294		

Sites	Row contributions				
	Qual	Component 1		Component 2	
		Corr	Contr	Corr	Contr
Mbalangi (East)	1	0.457	0.312	**0.543**	0.422
Diffa (North)	1	**0.956**	0.594	0.044	0.031
Bai Manya (West)	1	0.164	0.094	**0.836**	0.546

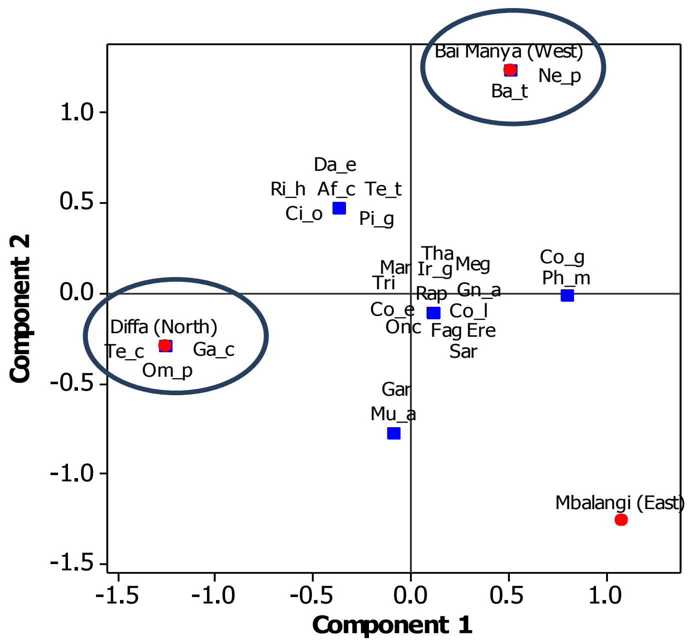

Figure 2. Distribution patterns of NTFP species across sites**.** Ba_t: *Baillonella toxisperma*, Ci_o: *Cinchona officinalis*, Co_g: *Cola grasilensis*, Co_l: *Cola lepidota*, Co_e: *Coula edulis*, Da_e: *Dacryodes edulis*, Fag: *Fagara* spp., Ga_c: *Garcinia cola*, Gar: *Garcinia sp*, Mu_a: *Mussularia acuminata*, Ir_g: *Irvingia gabonensis*, Ri_h: *Ricinodendron heudelotii*, Te_t: *Tetrapleura tetraptera*, Tr_a: *Trichoscypha abut*, Af_c: *Afromomum citratum*, Ne_p: *Nephthytis poissonii*, Ere: *Eremospatha* spp.*,* Gn_a: *Gnetum africanum*, Mar: *Maranthochloa* spp., Meg: *Megaphrynium* spp., Sar: *Sarcophrynium*, Tha: *Thaumatococcus* spp., Om_p: *Omphalocarpum procerum*, Onc: *Oncocalamus* spp., Ph_m: *Phllanthus meullerianus*, Pi_g: *Piper guineensis*, Rap: *Raphia* spp, Te_c: *Tetracarpidium conophorum.*

impacts.However, the results are lower than those reported by Nnanga et al. (2017) at the coastal forest area of Cameroon which might be due to very low disturbances in their study areas though both of them are

Table 6. Simple correspondence analysis of species abundance across sites.

Axis	Analysis of the contingency table		
	Inertia	Proportion	Cumulative
1	0.1737	0.5248	0.5248
2	0.1573	0.4752	1
Total	0.3309		

Name	Row contributions				
	Qual	Component 1		Component 2	
		Corr	Contr	Corr	Contr
Mbalangi	1	0.01	0.008	0.99	0.821
Diffa	1	0.616	0.234	0.384	0.161
Bai Manya	1	0.98	0.758	0.02	0.017

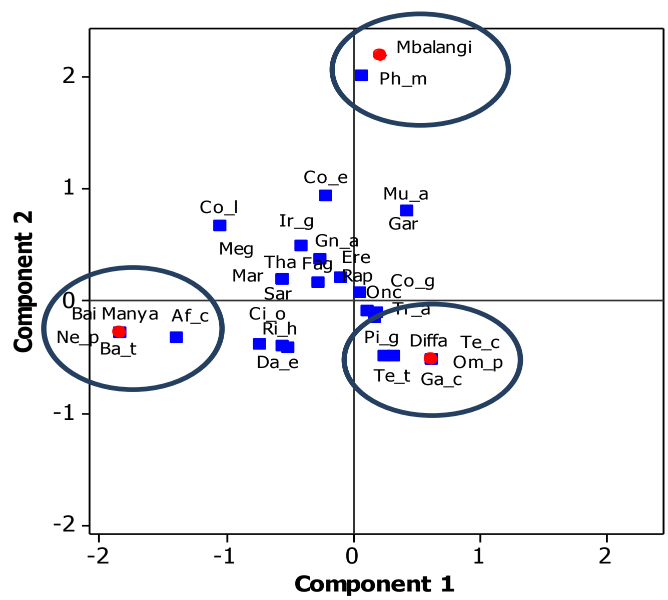

Figure 3. Abundance patterns of NTFP species across the different sites. Ba_t: *Baillonella toxisperma*, Ci_o: *Cinchona officinalis*, Co_g: *Cola grasilensis*, Co_l: *Cola lepidota*, Co_e: *Coula edulis*, Da_e: *Dacryodes edulis*, Fag: *Fagara* spp., Ga_c: *Garcinia cola*, Gar: *Garcinia sp*, Mu_a: *Mussularia acuminata*, Ir_g: *Irvingia gabonensis*, Ri_h: *Ricinodendron heudelotii*, Te_t: *Tetrapleura tetraptera*, Tr_a: *Trichoscypha abut*, Af_c: *Afromomum citratum*, Ne_p: *Nephthytis poissonii*, Ere: *Eremospatha* spp., Gn_a: *Gnetum africanum*, Mar: *Maranthochloa* spp., Meg: *Megaphrynium* spp., Sar: *Sarcophrynium*, Tha: *Thaumatococcus* spp., Om_p: *Omphalocarpum procerum*, Onc: *Oncocalamus* spp., Ph_m: *Phllanthus meullerianus*, Pi_g: *Piper guineensis*, Rap: *Raphia* spp, Te_c: *Tetracarpidium conophorum.*

within the same agro-ecological zone in Cameroon. Species with high economic value that are also the most (*Dacryodes* harvested *edulis, R. heudelotii*) were present across all sites suggesting that harvesting alone could

Table 7. Similarity measures across sites.

Site	Jaccard's Coefficient		Sorensen Coefficient	
	Bai Manya	Diffa	Bai Manya	Diffa
Bai Manya	-	-	-	-
Diffa	0.65	-	0.79	-
Mbalangi	0.60	0.52	0.75	0.69

Table 8. Species diversity across sites measured by Simpson's index**.**

Variable	Bai Manya	Diffa	Mbalangi
Simpson's index (D)	0.92	0.85	0.8
Reverse of Simpson' index (1/D)	12.6	6.59	7.85

not explain species distribution patterns in the SBFR. Since the fruits of these species are eating by animals, they in the dispersal of the seeds in the forest. In fact, some cosmopolitan species identified such as *R. heudelotii* and *Tetrapleura tetraptera* are indicators of fragmentation of forest stand and secondary forest (Moris, 2010; Reyes et al., 2014). *T. tetraptera* and *R. heudelotii* were abundant in the northern part of the forest. The northern part of the forest, classified as being mainly primary forest type has over the years witnessed an increase in illegal logging activities which led to the creation of gaps, an environment favourable to these species. *Irvingia gabonensis, C. edulis, C. lepidota, G. africanum, Eremospatha* species, *Laccosperma* species and *Trichoscypha* species were other cosmopolitan species found to be the most frequent at all the sites. They were present in more than 75% of transects. However, the very low volumes of *G. africanum* observed, demonstrate resource depletion since the species is a vine and needs trees for support and shade for effective growth. On the other hand, species unique to particular sites e.g. *G. kola, T. conophorum*, and *O. procerum* in Diffa, or *N. poissonii* and *B. toxisperma* in Bai Manya suggest that habitats have been altered such that their range is reduced. There is fragmentation which prevents gene flow, or overexploitation at different sites leading to local extinction (Morris, 2010). The three sites whose data were considered, Diffa is the most remote, and almost wholly dependent on the forest than the other sites in spite of sparse population. There has been serious degradation at Bai Manya, with extensive harvest of *G. africanum* and *R. heudelotii.* From Bai Manya westward, intensity of encroachment increases; Munyenge, the fourth site excluded from these analyses almost had no forest left as it has been replaced with cocoa plantations. This observation corroborates that of Zhu et al. (2015) who noted that, the southern portion of Yunnan tropical rainforest of south-western China was transformed into monoculture rubber plantation. The high abundance of some species at particular sites may suggest more restrained harvesting or thriving populations. This is difficult to compare given that no baseline or pristine conditions studies exist. Bai Manya and Diffa which are the least disturbed sites were the most similar, as a result of a large number of common species across sites. At Mbalangi, there has been active reforestation over the years, so the forest is actually artificial, and hence markedly different from the other sites. NTFPs that have survived across sites are resilient species that are also amendable to domestication, and hence similar to the planted forest in many ways. However, all sites had high species diversity (0.8 to 0.97). It has however been shown that functional diversity that takes into consideration linkages between species assemblages is more important in biodiversity conservation than simple taxonomic diversity (Moris, 2010; Aerts and Honnay, 2011). Hence, although highly diverse, the modified Mbalangi site is less representative of the SBFR than the other two sites, and this is shown by the similarity indices that actually take species composition into consideration. The least disturbed sites (Diffa and Bai Manya) are richer in species than Mbalangi. This is consistent with findings that tropical forests with minimal anthropogenic disturbances are centres of undescribed species richness (Giam et al., 2012; Gandhi and Sundarapandian, 2014).

According to the Intermediate Disturbance Hypothesis, moderate disturbances could be expected to have positive effects on species richness (Bongers et al., 2009). Harvests of NTFPs result directly in two types of disturbances, namely, shifts in mortality rate and shifts in reproductive rates; while direct deforestation for agriculture and building materials result in shifts in carrying capacity (Dornelas, 2010). All these forms of disturbances are present to varying degrees in the SBFR, with the result that at the more degraded sites like Mbalangi, NTFP species richness is highly affected negatively suggesting that the site is functionally isolated from the rest, and this isolation hinders any positive effects of disturbances (Bobo et al., 2006; Dornelas, 2010).

Conclusion

Species diversity and abundance was high in the forest sites of Bai Manya and Diffa as a result of moderate disturbances when compared with the site at Mbalangi which had greater disturbances. The results are significant for better management of the SBFR. The present rate of degradation is unsustainable whilst the forest is still under state protection; it will be more so under communal control. A more integrated approach that creates exploitation quotas for the different NTFPs could allow for natural regeneration to occur, under which more diverse species can result in improved functional relationships. More detailed studies are essential to better inform government conservation policy at this site, as a way forward.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Full Length Research Paper

Species composition and relative abundance of medium and large mammals in Mengaza communal forest, East Gojjam, Ethiopia

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Studies on the species composition, relative abundance and distribution of medium and large mammals were carried out from August 2015 to July 2016 in Mengaza communal forest. Data were collected using line transect technique. A total of twelve species of medium and large mammals were identified and recorded in the study area. Rock hyrax (*Procavia capensis*), porcupine (*Hystrix cristata*), honey badger (*Mellivera capensis*), vervet monkey (*Chlorocebus aethiops*), Abyssinian hare (*Lepus habessinicus*), black backed jackal (*Canis mesomelas*), klipspringer (*Oreotragus oreotragus*), olive baboon (*Papio anubis*), were among the medium mammals but Spotted hyena (*Crocuta crocuta*), aardvark (*Oryctropus afer*), bohor reed buck (*Redunca redunca*) and common duiker (*Sylvicapra grimmia*) were among the large mammals identified in the study area. Olive baboon (32.7%) was the most abundant species during dry and wet seasons. Mammalian species composition between the two habitats (natural forest and plantation) was not significant (^{X2} = 0.47, df =1, P > 0.05). However, there was seasonal variation in the abundance of individuals of medium and large mammals (^{X2} = 3.89, df = 1, P < 0.05). The area is facing severe degradation due to ^{human} population pressure. Therefore, there should be proper conservation of the forest to sustain the wildlife species living there.

Key words: Abundance, distribution, medium and large mammals, Mengaza Communal Forest, plantation species composition.

INTRODUCTION

Mammals are diversified both structurally as well as functionally (Yonas and Fikresilasie, 2015). Class Mammalia is composed of 5,487 species and more than 1150 species of mammals are found in Africa (Borges et al., 2014). East Africa is rich in mammalian fauna are the (Zerihun et al., 2012a). Topographic diversity and climate most significant predictors of mammalian species diversity (Melaku, 2011) in which heterogeneous habitats

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support different species of mammals (Vaughan et al. 2000).

Ethiopia is one of the African countries known for highest mammal species richness (Zerihun et al., 2012b), and possesses more than 320 mammals, of these, 36 are endemic to the country (Alemneh, 2015a, b; Rabira et al., 2015). The highest level of endemicity is credited to the large extent of highlands (Yalden and Largen, 1992). More than 60% of the mammal species in Ethiopia are medium and large- size (Dereje et al., 2015). Most populations of medium and large mammals are severely depleted in the country including protected areas (Rabira et al., 2015). It is due to growth of human population, habitat loss, fragmentation, weak management of the protected areas and deforestation (USAID, 2008).

Knowledge on local fauna is essential for future conservation strategies and provide basic information for more complex ecological and biogeographical studies (Botelho et al., 2012), and which is the first step for conservation action (Botelho et al., 2012; Fornitano et al., 2015). Investigations on mammalian diversity, abundance and habitats provided information of the status of populations for appropriate conservation actions (Galetti et al., 2009; Rabira et al., 2015; Yosef, 2015). Hence, lack of survey may hinder preparation of appropriate management plan in the protected areas (Fornitano et al., 2015). The fauna of Ethiopia is not well investigated (Dawit and Afework, 2008; Alemneh 2015 b; Dereje et al., 2015). There is little quantitative information about how the tropical forest mammals change (Ahumada et al., 2011).

Most of the diversity and population ecology of medium and large mammals are targeted on National Parks and sanctuaries of the country (Mohamed and Afework, 2014), but outside of the protected areas records and conservation status of the different species of mammals are poorly known (Rabira et al., 2015). There are about 48 protected areas (National Parks, Wildlife Reserves, Sanctuaries, and Controlled Hunting Areas) in the country (Young, 2010). These protected areas cover roughly 16.4 % of the countries land area (Melaku, 2011; Alemneh, 2015 b).

So more should be done and surveys on the protected and potential areas should be carried out. Assessments on the diversity and abundance of wildlife resources is an important components of conservation programs (Fornitano et al., 2015; Yosef, 2015), that it can locate areas of high diversity of mammals and help managers understand effects of habitat loss and habitat fragmentation (Dawd and Solomon, 2013).

There was no study on diversity and abundance of the mammalian species in the study area conducted yet. Therefore, the present study focuses on species composition, relative abundance and distribution of medium and large mammals in Mengaza Communal Forest, East Gojjam. Comparison of medium and large sized mammals between habitats and seasons were assessed.

MATERIALS AND METHODS

Mengaza Communal Forest is found in Dejen woreda, East Gojjam zone in the northwestern part of Ethiopia. According to Derba Medroc (2008), the study area is located between 10°12’0” to 10°14’30” N and 38° 6’30” to 38°8’0^{o} E at about 238 km north of Addis Ababa. The total area coverage of the study area is 265 ha of which 187 ha is covered with natural forest, which is called Mengaza and 78 ha is covered with plantation (modified area), which is known as Amarie (Figure 1). The altitude of the natural forest area ranges from 2331 to 2381 m a.s.l. and the plantation altitude ranges between 2408 to 2459 m a.s.l. The study area was protected by local community members since 1980s (Derba Medroc, 2008).

Before the actual data collection pilot survey was conducted in August 2015. During this period, information like types of vegetation, topography and others were collected. Data were collected using line transect method (Verman and Sukumar, 1995). A total of six transect lines were systematically established in both natural forest (Acacia woodland) and plantation in which among the, transects four of them were from natural forest and the remaining two from plantation. The location of each transect was marked by global positioning system (GPS). The length of transects ranged from 0.8 to 1.05 km depending on the topography of the habitat and the distance between each transect was 1 to 2 km to avoid double counting (Figure 1).

Both direct and indirect techniques were employed in the field. Surveys in the sampled areas were performed twice a day, early in the morning (6:00 to 8:00) and late in the afternoon (16:00 to 19:00) when most mammals were more active in the study area (Meseret and Solomon, 2014; Dereje et al., 2015). Care was taken by the observer not to disturb the animals (Dawd and Solomon, 2013). During data collection, an observer walks on foot along each transect and directly count all the individuals sighted with their respective species using unaided eyes and binocular.

Transects were covered from opposite ends in order to minimize bias (Yosef, 2015). Information like species, the number of individuals, location, habitat type, sex and age were recorded (Campose et al., 2013). Field identification of mammalian species was carried out using mammal’s field guild of Blower (1969) and Gelderen (2015). Mammals in the study area were categorized in to medium (those between 2 and 7 kg) and large (those over 7 kg body mass) mammals (Dereje, 2015). In addition to direct observation of live animal indirect evidence was also used to collect data. Indirect evidence is very useful when surveying animals such as carnivores that are naturally rare, elusive, found at low densities and difficult to capture repeatedly. So the presence of medium and large mammals were also been precisely indicated using indirect evidences, using sounds, spines, burrows and faecal droppings (Campos et al., 2013; Borges et al., 2014; Dereje et al., 2015). The collected data were tabulated and analyzed with appropriate statistical methods. Shannon-Wiener diversity Index (H’):

$$(H' = -\sum (Pi \ln Pi)$$

Where *H’* is Shannon index of diversity, *Pi* is the proportion of individuals of species in a sample and ln = Natural logarithm was used to compute diversity of medium and large mammals in the study area (Shannon and Wiener, 1949).The evenness of mammalian species was calculated as:

$$E = H' / H'max$$

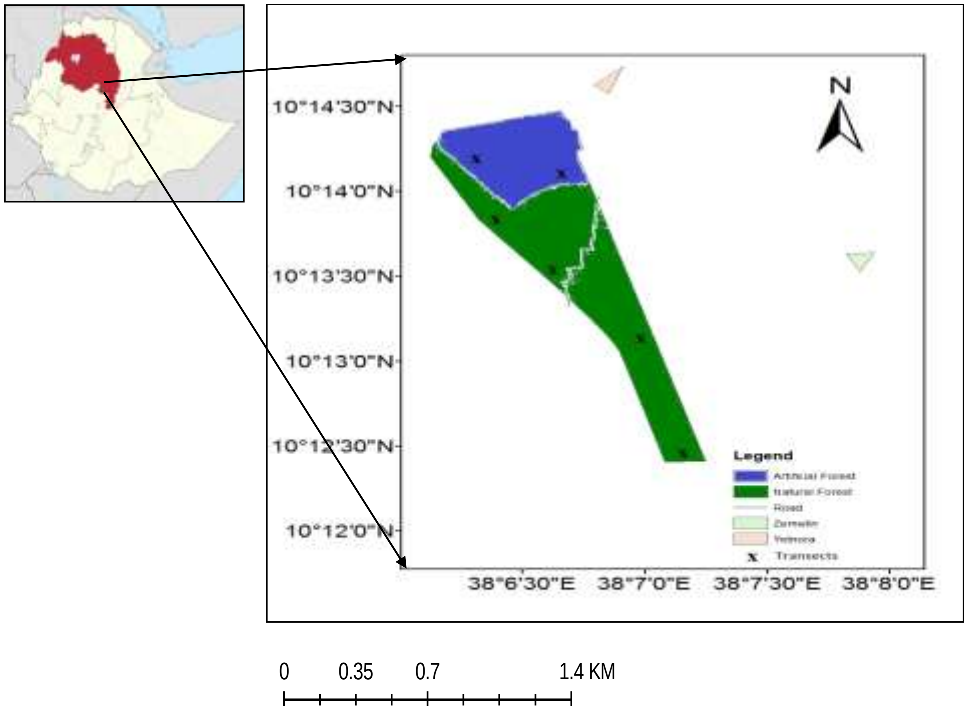

Figure 1. Map of the study area.

Where H' is observed index of diversity and H' max=ln(S); S = the number of species in each habitat; ln = Natural logarithm was computed to determine the number of individuals of the mammalian species between habitats and seasons as used by Dereje et al. (2015). The relative abundance of each species (observed medium and large mammals) in the two habitat types were computed using the formula;

$$\text{Abundance} = \frac{\text{total number of individual of a species}}{\text{total number of individuals species in the sampled habitat}} \times 100$$

as used by Botelho et al. (2012) and Rabira et al. (2015).

Chi-square test was used to compare the seasonal variations in species composition and abundance of individuals between habitats. Simpson similarity index (SI) was also computed to assess the similarity between the two habitats with reference to the composition of species.

$$SI = 2C/ I+II$$

Where: SI = Simpson's similarity index; C = the number of common species to all two habitats; I = the number of species in habitat one (natural forest) and II = the number of species in habitat two (plantation forest)

RESULTS

A total of 12 medium and large mammal species under 11 families were identified in both of the study area during the dry and the wet seasons. The species include Aardvark (*Orycteropus afer*), Abyssinian hare (*Lepus habyssinicous*), Rock hyrax (*Procavia capensis*), Common duiker (*Sylvicapra grimmia*), Bohor reed buck (*Redunka redunka*), klipspringer (*Oreotrgus oreotragus*), Spotted hyena (*Crocuta crocuta*), Black backed jackal (*Canis mesomelas*), Honey badger (*Mellivora capensis*), Porcupine (*Hystrix cristata*), Vervet monkey (*Chlorocebus aethiops*) and Olive baboon (*Papio anubis*). Species composition in the natural forest was higher, than in the plantation. In the study area the natural forest contained 11 mammal species and the plantation area contained eight species. The variation was not significant ($^{\chi 2}$ = 0.47, df =1, P > 0.05).

A total of 315 individuals of medium and large mammals were recorded from Mengaza communal forest area during both seasons in which of the recorded mammalian species, Olive baboon (*P. anubis*) was the most (32.7%) abundant species followed by vervet monkey (*C. aethiops)* (18.7%) during both seasons, but Aardvark (*O. afer)* was the least abundant species during both seasons (Table 1). There was significant seasonal variation in abundance of medium and large mammals ($^{\chi 2}$ = 3. 89, df= 1, P < 0.05). Majority (55.6%) of the species was observed during the dry season and the remaining 140 (44.4%) individuals were observed during the wet season. *P. anubis* was the largest species during both the dry (32%) and the wet (33.6%) seasons (Table 2).

There was significant variation in abundance between

Table 1. Number of individual species, and their relative abundance of medium and large mammals identified in the study area.

Family	Common name	Scientific name	No. of individuals	Relative abundance (%)
Oryctropodidae	Aardvark	*Orycteropus afer*	4	1.3
Leporidae	Abyssinian hare	*Lepus habyssinicous*	16	5.1
Procaviidae	Rock hyrax	*Procavia capensis*	30	9.5
Bovidae	Common duiker	*Sylvicapra grimmia*	19	6.0
Reduncinae	Bohor reed buck	*Redunka redunka*	29	9.2
Bovidae	Klipspringer	*Oreotrgus oreotragus*	15	4.8
Hyaenidae	Spotted hyena	*Crocuta crocuta*	5	1.6
Canidae	Black backed jackal	*Canis mesomelas*	9	2.8
Mustelidae	Honey badger	*Mellivora capensis*	11	3.5
Hystricidae	Porcupine	*Hystrix cristata*	15	4.8
Cercopithea	Vervet monkey	*Chlorocebus aethiops*	59	18.7
Cercopithecidae	Olive baboon	*Papio anubis*	103	32.7
Total			315	100

Table 2. Seasonal variation in abundance of medium and large mammalian species in the study area.

Species	Total number of individuals and their percentage	
	Dry (%)	Wet (%)
Oryctropus afer	2(1.1)	2(1.4)
Lepus habessinicus	9(5.1)	7(5)
Procavia capensis	17(9.7)	13(9.3)
Sylvicapra grimmia	11(6.3)	8(5.7)
Redunca redunca	19(10.9)	10(7.1)
Oreotragus oreotragus	8(4.6)	7(5)
Crocuta crocuta	3(1.7)	2(1.4)
Canis mesomelas	5(2.9)	4(2.9)
Mellivera capensis	6(3.4)	5(3.6)
Hystrix cristata	7(4)	8(5.7)
Chlorocebus aethiops	32(18.3)	27(19.3)
Papio anubis	56(32)	47(33.6)
Total	175(100)	140(100)

natural forest and plantation habitats (χ^2 = 90.670, df = 1, P < 0.05). High number (135) of individual mammals was recorded in natural forest habitat in which 40 individuals were recorded from the plantation during the dry season also, 107 individuals in natural forest and 33 individuals were recorded from the plantation during the wet season.

Diversity index (H') and evenness (E) of medium and large mammals varied between the two habitats at different seasons. During the dry season higher diversity of medium and large mammalian species was observed in the natural forest (H' = 3.17) but the diversity in the plantation was lower (H' = 2.17) during the same season. The higher and lower even distribution was registered in the natural forest (E =1.32) and plantation forest (E = 1.11), respectively. Higher number of species (11) was recorded in the acacia woodland during the dry season and seven species were recorded from the plantation during the same season, but which was not significant at (χ^2 = 0.889, df = 1, P > 0.05) (Table 3).

During the wet season higher diversity of medium and large mammalian species was also observed in natural forest (H' = 3.089) and the diversity was lower in the plantation (H'=1.653). The higher and lower even distribution was recorded in the natural forest (E =1.40) and plantation (E=0.79), respectively during the same season. The species richness was higher (9) in the natural forest during the wet season (Table 4). There was no significant difference (χ^2 = 0.059, df = 1, P > 0.05) in

Table 3. Species diversity between habitats during the dry season.

Habitat type	No. of species	Abundance	SWI (H')	H'max	H'/H'max (E)
Natural forest	11	135	3.17	2.39	1.32
Plantation	7	40	2.17	1.95	1.11

Table 4. Species diversity between natural forest and plantation during the wet season.

Habitat type	Number of species	Abundance	SWI(H')	H'max	H'/H'max(E)
Natural forest	9	107	3.089	2.197	1.40
Plantation	8	33	1.653	2.079	0.79

Table 5. Species similarity between the acacia forest and the plantation.

Mammals in Natural forest (I)	Mammals in plantation (II)	Common species of habitat I and II	Similarity Index SI = 2C/I+II
Canis mesomelas	*Canis mesomelas*	*Canis mesomelas*	
Chlorocebus aethiops	*Crocuta crocuta*	*Crocuta crocuta*	
Crocuta crocuta	*Hystrix cristata*	*Hystrix cristata*	
Hystrix cristata	*Lepus habessinicus*	*Lepus habessinicus*	
Lepus habessinicus	*Mellivera capensis*	*Mellivera capensis*	
Mellivera capensis	*Sylvicapra grimmia*	*Oryctropus afer*	
Oreotragus oreotragus	*Redunca reduca*	*Sylvicapra grimmia*	
Oryctropus afer	*Oryctropus afer*		
Papio anubis			
Procavia capensis			
Sylvicapra grimmia			
∑S=11	∑S=8	∑S=7	SI=0.74

mammalian species diversity during the wet and dry seasons in the study area (Table 4). Simpson similarity index (SI) of medium and large mammal species between the two habitats in the study area was 0.74. This indicated that 74% of the species were common for all two habitats (Table 5).

About 66.7% (n = 8) of the species were diurnal, it included vervet monkey (*C. aethiops),* Abyssinian hare (*L. habessinicus),* klipspringer *(O. oreotragus),* Olive baboon (*P. anubis),* Rock hyrax (*P. capensis),* Bohors reed buck *(R. reduca),* Common duiker (*S. grimmia)* and Black backed jackal *(C. mesomelas).* But about 33.3% (n = 4) of the species were nocturnal these were *C. crocuta, H. cristata, M. capensis, O. afer.* The variation in activity pattern was not statistically significant (χ^2 = 1.33, df =1, P > 0.05).

DISCUSSION

A total of 12 species of medium and large sized wild mammals were identified in Mengaza communal forest. Similarly Zerihun et al. (2012a) recorded 18 species of medium and large sized mammals in and around Wondo Genet Forest patch, southern Ethiopia, on the other hand, Zerihun et al. (2012b) also recorded 19 species of large mammals. In Borena-Sayint National Park, south Wollo, Ethiopia, Meseret and Solomon (2014) recorded 23 medium and large mammals. Mengaza Communal Forest was not as rich in mammalian species diversity, the reason might be due to disturbance and low quality of habitat in the forest area, because guarding is not strengthened by communal law.

Food availability and other factors such as climate, geology and soil determined the distribution of wildlife populations in their natural habitats (Meseret and Solomon, 2014). According to the present study, medium and large sized mammals showed variation in composition between the two habitats and between seasons. Higher diversity of mammalian species was recorded in the natural forest habitats during both seasons. This is probably due to the presence of high vegetation diversity.

Similarly, earlier studies in different parts of Ethiopia revealed that mammalian species diversity is often high in areas where there are sufficient food resources and volume of habitat and available water sources (Dawud and Solomon, 2013). On the other hand, less diversity of mammalian species in plantation habitats during both seasons was probably related to the presence of more anthropogenic impact than the natural forest. The natural forest is relatively far from human settlements so that human impact was minimal.

The ecological preference and evolutionary adaptation of mammalian species play a role in their occurrence and abundance in different habitat types (Dawd and Solomon, 2013; Rabira et al., 2015). Studies noted the correlation of mammalian distribution and their habitat associations mainly with better availability of resources and protection. Higher even distribution was observed in the natural forest during both dry and wet seasons and lower even distribution was recorded in the plantation during both dry and wet seasons.

The possible explanations for this could be due to high number of livestock and pack animals were grazing near to the plantation area. Similar study in Kaka fragments has discovered the highest value of even distribution of mammals in the natural forest habitats in both seasons (Zerihun et al., 2012a). Higher number of medium and large mammalian species was recorded in the natural forest habitats and also recorded during the dry season than the wet season. Hence, their abundance significantly varied between habitats and between seasons as it was recorded by Zerihun et al. (2012b) and Dereje et al. (2015). Olive baboon (*P. anubis*) was highly abundant compared to other species recorded in the study area. Olive baboon is known to be widely distributed in Africa in a wide variety of habitats (Kingdon, 2013) and this might be due to their feeding behavior and high reproductive success.

Although the area is protected by the community, some people were seen to intrude the area repeatedly due to loosen communal law and inactiveness of Governmental bodies. Hence, due to farming activity high number of livestock and people involved around the area. Human activities like collection of fire wood, cutting grass and other activities are often affecting the study area which in turn affects wildlife in the area. Therefore, supporting Mengaza communal forest from governmental offices could greatly increase its effectiveness in biological conservation. Hence, there should be an immediate conservation management action to enhance the diversity and abundance of medium and large mammalian fauna in the study area. About 66.7 % of the species were diurnal. This might be due to human disturbance which mostly happened in daytime, so human disturbance should be a main disturbance factor to the activity of diurnal wildlife in the study area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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