Diversity, Abundance and Distribution of Mammals in Fragmented Remnant Forests around Asella Town, Ethiopia

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***Abstract*- Survey on diversity, relative abundance, and distribution of mammals in fragmented remnant montane forest of Child Care Center and School of Agriculture was conducted from March to July 2013. Trapping, lines transect and indirect survey techniques were used. Information on abundance and species composition of matured trees was collected. Data were organized and analyzed using descriptive statistics. A total of 22 species of mammals belonging to five orders were recorded. From the trapped species of mammals, Stenocephalemys albipes was most abundant while Arvicanthis abyssinicus was least. From non-trapped groups of mammals, the most abundant was Colobus guereza whereas Leptailurus serval and Poecilogale albinucha were least recorded. Most of the species were widely distributed. However, Mus mahomet, Arvicanthis abyssinicus, Redunca redunca and Chlorocebus pygerythrus were recorded only from the School of Agriculture and in the same way Papio anubis was recorded from Child Care Center. The majority of the species (13) belonging to 108 individuals were recorded from thick canopy forest and nine species from grassland habitat. Plantation with secondary growth habitat was the most diversified habitat while grassland was the least. As the area is rich in mammal and other species, urgent conservation action is highly recommended.**

***Keywords*: Habitat fragmentation, mammal, montane forest, relative abundance, species composition.**

I. Introduction

Ethiopia is physically and biologically a diverse country as the result of extensive altitudinal variation [1]. The Afromontane forest of Arsi Mountains is endowed with varieties of large and medium sized mammals. However, these areas possess dense concentration of human population as the result of suitable weather and climatic condition of the surrounding area [2]. The increase in human population in the area was the cause of biodiversity loss and habitat fragmentation and degradation.

In many parts of the world, human activities have altered patterns of landscape, habitat quality and distribution of species [3]. In the tropical region, population density and agricultural expansion have resulted in forest fragmentation and habitat loss [4]. The extensive continuous natural areas are fragmented into small remnant habitats [3]. Even though the mechanism of impacts on populations is poorly known, habitat fragmentation is often considered as a major threat to biodiversity [5]. It may make species to depend and distribute on increasingly smaller patches of remnant semi-natural habitat and green corridors such as hedgerows, wooded field margins, infrastructure edges and small forest patches [6]. Crop cultivation, pasture and human residence near fragmented forest habitat also determine the species composition and abundance of mammals [3], [7]. Species composition and abundance change due to fragmented landscapes. In addition, the remnant native vegetation left after such modifications may also be reduced in size and disconnected from adjacent, continuous habitat leading to reduction in animal and plant species. This excludes certain species or increases the probability of extinction [7]. The rate of species extinction in an isolated patch is inversely related to the size because it less likely provides food, cover and other resources necessary to support the native wildlife community [8].

Many habitats of mammals are undergoing degradation due to high human encroachment for agriculture, pastureland, collection of firewood, settlement and for other human activities [9-12]. Even though Ethiopia possesses many mammal fauna, limited studies have been carried out in different parts of the country focusing largely in protected habitats [13-16].

The present study areas were traditionally protected for different purposes by government and public as sacred forest before the natural Afromontane forest in the area was deforested. This fragmented remnant habitat is a witness for the previous composition of biodiversity of the surrounding area. However, there was little research carried out on the biodiversity of the area. The general objective of this research is to conduct surveys on species composition, relative abundance, and distribution of mammals of the fragmented dry evergreen remnant montane forest habitat around Asella town, South Eastern Central Ethiopia.

II. MATERIALS AND METHODS

A. Study Area

The study was carried out in the remnant fragmented dry evergreen montane forest on the premises of the Ethiopian Orthodox Church Child and Family Affairs Organization, Debir Kidus Sisay Hailemichael Memorial Child Care Center of Asella town, hereafter, called Child Care Center [17]. The fragmented habitats of Adama Science and Technology University, School of Agriculture of Asella Campus, hereafter, called School of Agriculture were also incorporated into the study area. The study area is located approximately at 07°55′22″ to 07°56′24″ N latitude and 39°05′41″ to 39°08′36″E longitude at altitude of 2500 m a.s.l. near Asella town and about 175 km away from Addis Ababa (Figure 1).

The Child Care Center compound consists of fragmented remnant Afromontane forest. Even though the compound is under the Ethiopian Orthodox Church Child and Family Organization, previously it was used as a palace or residence for different administrative officers of Arsi Province during the Imperial Regime (1930-1974). During the Italian occupation, it also served as Italian residence by improving many infrastructures. During the downfall of Derg or two and half decades ago, many infrastructures were damaged and some properties were also stolen by the local community. In 1986, the Ethiopia Orthodox Church requested the compound to use for provision of different services to the local community. In 1988, the request for orphan children care was granted. Then the orphan care center was established in 1994 to provide residential service with full care and support [17].

Although the compound of the center is a small protected remnant forest 22.11 ha (221,100 m^2), it was the best representative of the surrounding area before it was deforested. It has thick mixed natural and plantation forest dominated by *Podocarpus* trees. Even the compound of the Child Care Center possesses *Podocarpus* tree whose diameter at breast height measures more than 3.82 m which is locally known as ‘Yezafoch Abat’, meaning the father of trees. The compound has many small and large mammals and other organisms. It is delimited from the north and south by two streams that emanate from nearby Mount Chilalo [17].

Similarly, the School of Agriculture which includes Athlete Tirunesh Dibeba Athletics Academy is very large compounds 261.05 ha (2,610,540 m^2) with different fragmented habitats. The compound consists of natural and plantation forests and grassland habitats [17].

The School of Agriculture is located at the periphery of Asella town which was handed over to the Adama University from Oromia Regional State, Agriculture and Rural Development Bureau. Currently the school is handed over to the recently established Arsi University and named as College of Agriculture and Environmental Sciences.

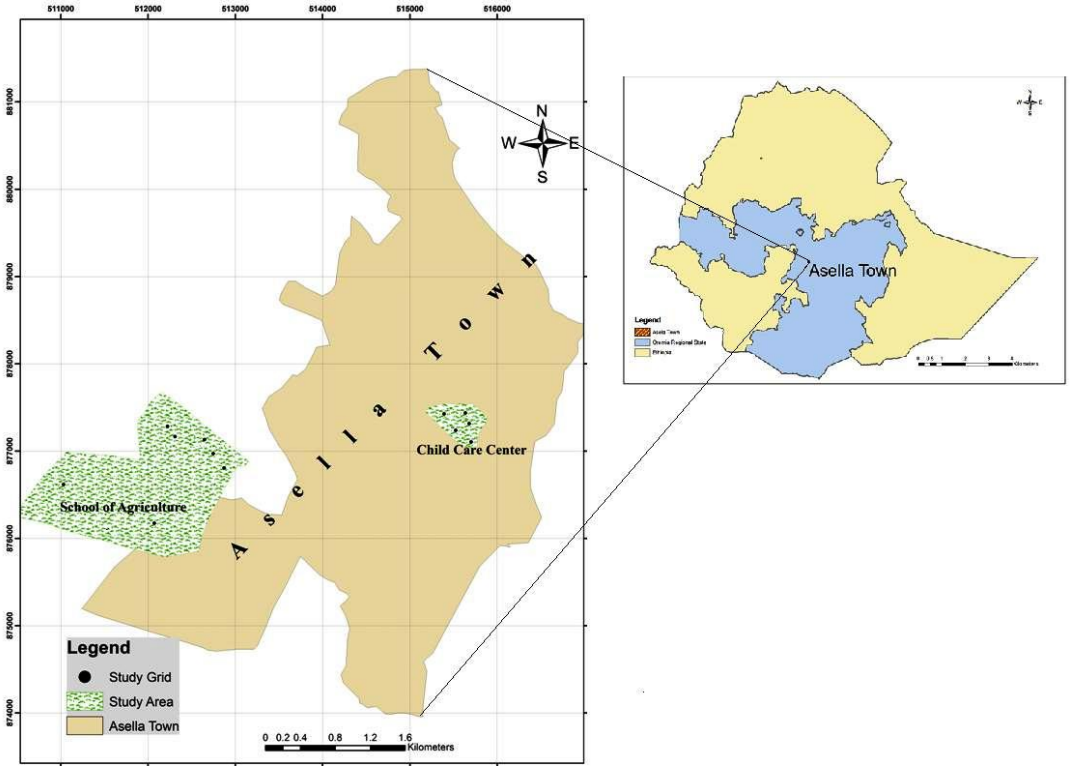

Figure 1. Map of the study area.

B. Methods

The study was carried out from March to July 2013. During each field survey study, information on species composition and relative abundance of mammals and their major threats were collected. The threat part of the result was already published by Mohammed and Afework [17].

During the preliminary survey, all the available and relevant information such as vegetation types, different habitats and size and location, roosting and foraging sites and potential threat factors were recorded. Based on the different vegetation and habitat types and size, grids and transect lines were randomly selected.

Line transect survey technique was used to estimate population density for a variety of mammal species in tropical forests [17]. In many cases, indirect survey methods such as counts of dung or dens were used because of the poor visibility in these forests. Three line transects that run from east to west in the Child Care Center compound with at least 200 m apart was established. The last two transect lines at the margin of north and south of the compound was deliberately adjusted to sample mammals at the edge. Along each transect line starting from the end corner from east; sampling grid with size of 50x50 m^2 at interval of approximately 200 m was formed for the survey of small mammals and vegetation. In addition, two grids from the School of Agriculture were used. A total count of natural trees with diameter at breast height greater than 0.48 m and height greater than 10 m were carried out. Slight adjustment in the position was made when the grid falls on infrastructures.

For the survey of mammals in the study area, the procedures of Sutherland [18] and Krebs [19] were used. Sherman live traps were used for small mammals. Other methods that complement trapping were also used for the non-trapped mammals. Some of them were owl pellet, carnivore scat, dental impression, footprint, runways, rub marks, burrow, mole rate mound, sound, and call, nest, and roosting sites. Species specific methods like scent stations, den count, associated species and food catches or remains were also used. Direct and indirect observations were recorded at the maximum of 100 m distance from both left and right side during walking along the transect line.

For the bat survey, all possible bat roosting sites like roof/ceiling, mature tree holes, cracks, branches, leaves and crevices that seem to contain bats were thoroughly observed during the day along the transect line and in the radius of 100 m from the transect line.

For rodents, in each trapping grid, 25 Sherman live traps were laid at 10 m interval from each other or trap station. Based on the suitability of the habitat, some traps were placed and fastened in thick forest branches (between 1-2 m height) to survey arboreal small mammals. Each trap was baited with peanut butter mixed with roasted barely flour and checked early in the morning (between 7:00 and 8:30 a.m.) and late afternoon (between 4:30 and 6:00 p.m.) for three consecutive days. The survey was conducted in two sessions at an interval of three months in each selected permanent sampling grids. Near the sampling grids, subterranean rodents were recorded from active burrow and digging. During trapping and handling of the animal, all necessary care was taken in order not to harm them and to avoid risks caused by mishandling. To survey medium and large mammals walking along a transect line, normal speed was carried four times a day (early in the morning, afternoon, late in the afternoon and evening or night) for three consecutive days in the two sessions. In all occasions, quick and careful handling of trapped animals was applied to minimize impact on the individuals [20]. In most cases, total count was used for large and medium sized mammals based on the behavior and nature of animal and using small size of the area.

For vegetation description, sampling grid of small mammal survey was used. The main purpose of vegetation description was to know the nature and quality of habitat and the existing mammal species in the study area. Based on the growth form and homogeneity of vegetation, a quadrant of 20x20 m^2 for tree dominated; 10x10 m^2 for shrub dominated and 1x1 m^2 for herb dominated habitats in the grids were taken from the center of the grid. For trees with diameter at breast height greater than 0.48 m and height of more than 10 m, a total count was made in the Child Care Center compound.

Information from all live trapped mammals on types of species, weight, sex, approximate age (juvenile, sub-adult, adult) and reproductive conditions were recorded. Reproductive conditions for females, sign of lactation, pregnancy, or hymen perforation and for males, testes size and position were used.

In this study, for all individuals observed and trapped, different identification mark or signals were used. For all live trapped individuals, fur clipping was used for marking by clipping hairs in unique patterns on their back and underside and released in the site of capture for capture-mark-recapture study. For medium and large mammals, all available and relevant information was gathered by direct and indirect observation like nesting/roosting/den/burrow, pellet/food remains, scat, foot print, rub marks, scent, and sound/call. Representative vegetation types were also identified.

In the present study, data on the dominant and matured tree composition, life form composition and structure of vegetation were collected. Particularly, mature dominant total tree count was made for the Child Care Center because of its relatively small manageable area.

The relative abundance of each trapped species was computed based on the percentage trap success or the total number of individual capture per 100 trap nights from Sherman live traps. The relative abundance was computed based on capture-mark-recapture, total count, and number of population from indirect observation. For none-trapped mammals, abundance was computed from mean number of individuals observed from observation session per day and season. All the observed (direct or indirect) and trapped mammals were identified to species level by using the taxonomic characters listed in Kingdon [9-11], Yalden and Largen [21], Afework [14] and Nowak [22].

The density and frequency of vegetation was measured and computed based on the individual species count from the quadrant. Each individual plant was identified to the species level in the field by using the available literature and expert and by comparing the collected specimen with the collection in National Herbarium of Addis Ababa University.

Both qualitative and quantitative data were analyzed with descriptive statistics. SPSS Version 16.0 statistical program, PAST version 1.62 Statistical Package (Software) and appropriate statistical methods such as mean and percentage were used. Gini Simpson and Shannon-Wiener Diversity Index were computed by using PAST.

III. RESULTS

The remnant natural habitat and forest type was characterized as dry evergreen montane forest type. The compound of the Child Care Center was small but contains more remnants of the original forest. It also possesses comparably less modified vegetation and plantations.

Although currently more attention is given to plant indigenous tree species, *Juniperus procera, Podocarpus falcatus* and *Hagenia abyssinica*; the planted older plantations were composed of exotic tree species: *Eucalyptus globulus*, *Cupressus lusitanica* and *Pinus radiata*. About 85% of the border line is planted with *Eucalyptus globulus* and *Cupressus lusitanica*.

The majority (55%) of the Child Care Center compound area is covered with trees whereas about 15% is covered with herbs and open land including the land occupied by different infrastructures in the compound. The remaining 35% is covered with bushes and secondary growth forms. About 75% of the land in School of Agriculture is covered with vegetation with herb growth form and shrubs (15%). The coverage of trees of natural and plantation accounted for about 10% of the total area.

The tree species composition and relative abundance recorded from a total count of matured trees whose diameter at breast height (DBH) is greater than 0.48 m and height of more than 10 m is presented in Table 1.

A total of 449 trees were recorded of which *Podocarpus falcatus* was the dominant one in relative abundance or frequency as well as in diameter at breast height. From the total of 146 counted *P. falcatus* mature trees, 7 were extremely large size with DBH of above 2.42 m. The largest and the one that seems to be the oldest tree named by the local people “Yezafoch Abat” also belonged to this taxon. It has the largest diameter at breast height of more than 3.82 m. The second and third most abundant tree was *Eucalyptus globulus* (19.82%) and *Cupressus lusitanica* (18.93%) although the DBH measurement is less than 1.75 m (Table 1). Most trees (322) have a DBH measurement of less than 1.11 m. From the tree species, whose DBH measurement is greater than 0.48 m, *Hagenia abyssinica* and *Maesa lanceolata* were the least in relative abundance (Table 1).

TABLE 1
RELATIVE TREE SPECIES COMPOSITION AND ABUNDANCE AT THE CHILD CARE CENTER

Species name	Diameter at breast height (DBH) (m)				Total	Relative abundance (%)
	0.48-1.11	1.15-1.75	1.78-2.39	2.42 & above		
Podocarpus falcatus (Thunb.) C.N. Page	51	55	33	7	146	32.52
Eucalyptus globulus Labill	89	-	-	-	89	19.82
Cupressus lusitanica Mill	85	-	-	-	85	18.93
Schefflera abyssinica (Hochst. ex Rich.) Harms	12	12	-	-	24	5.35
*Juniperus procera (*Hochst. ex Endl.)	19	2	-	-	21	4.68
Schefflera volkensii Harms	10	7	-	-	17	3.79
Pinus radiate Don.	13	-	-	-	13	2.90
*Croton macrostachyus (*Hochst. ex Del.)	8	3	-	-	11	2.45
Flacourtia indica (Burm.f.) Merr	7	4	-	-	11	2.45
Galiniera saxifraga Bridson	10	1	-	-	11	2.45
Olinia rochetiana A.Juss	8	1	1	-	10	2.23
Allophyllus abyssinicus (Hochst) Radlk	3	1	-	-	4	0.89
Bersama abyssinica Fresen	3	-	-	-	3	0.67
Hagenia abyssinica (Brace) J.F. Gmel	2	-	-	-	2	0.45
Maesa lanceolata Forssk	2	-	-	-	2	0.45
Total	322	86	34	7	449	100

One of the significant and prominent vegetation types in the School of Agriculture is open grassland and farmland. This vegetation serves as a habitat for livestock and Bohor Reedbuck grazing field. The remnant forest and plantation growth serves as ideal habitat and refugia for many mammals.

A total of 22 species of mammals belonging to five orders (Rodentia, Primate, Cetartiodactyla, Carnivora and Tubulidentata) were recorded from both the Child Care Center and from School of Agriculture (Table 2).

In addition, bats were also observed during evening and night while flying. Most the species recorded belonged to the Order Rodentia (Table 2).

Out of the 10 species of rodents recorded, eight were captured by Sherman live traps whereas the remaining two species *Tachyoryctes splendens* and *Hystrix cristata* were indirectly observed in the different study grids from mole rat mounds and quill.

A total of 750 trap nights (375 for each dry and wet trapping session) were used. Out of these, 450 and 150 trap nights were used in the Child Care Center study grids and School of Agriculture study grids, respectively. A total of 289 individuals of rodents were captured of which 203 individuals were new captures and 86 recaptures (Table 3).

TABLE 2
LIST OF SPECIES OF MAMMALS RECORDED FROM DIFFERENT HABITATS (MODIFIED FROM MOHAMMED AND AFEWORK [17])

Order	Species	Common name	Species Authority
Rodentia	*Arvicanthis abyssinicus*	Abyssinian Grass Rat	Ruppell, 1842
	Hystrix cristata	Crested porcupine	Linnaeus, 1758
	Lophuromys chrysopus	Ethiopian Forest Brush-furred Rat	Osgood, 1936
	Lophuromys flavopunctatus	Yellow Spotted Brush-furred Rat	Thomas, 1888
	Mastomys natalensis	Natal Multimammate mouse	Smith, 1834
	Mus mahomet	Mahomet's mouse	Rhoads, 1896
	Rattus rattus	House rat	Linnaeus, 1758
	Stenocephalemys griseicauda	Gray tailed narrow-headed rat	Frick, 1972
	Stenocephalemys albipes	White footed rat	Rüppell, 1842
	Tachyorctes splendens	East African Mole Rat	Ruppell, 1835
Primate	*Chlorocebus pygerythrus*	Vervet Moneky	Cuvier, 1821
	Colobus guereza	Eastern Black-and-white Colobus	Ruppell, 1835
	Papio anubis	Olive Baboon	Lesson, 1827
Cetartiodactyla	*Redunca redunca*	Bohor Reedbuck	Pallas, 1767
	Sylvicapra grimmia	Common Duiker	Linnaeus, 1758
	Traglaphus scriptus meneliki	Menelik's Bushbuck	Neumann, 1902
Carnivora	*Civettictis civetta*	African Civet	Schreber, 1776
	Crocuta crocuta	Spotted Hyeana	Erxleben, 1777
	Leptailurus serval	Serval	Schreber, 1776
	Herpestes sanguineus	Slender Mongoose	Ruppell, 1835
	Poecilogale albinucha	African Striped Weasel	Gray, 1864
Tubulidentata	*Orycteropus afer*	Aardvark	Pallas, 1766

TABLE 3
SPECIES COMPOSITION AND RELATIVE ABUNDANCE OF SMALL MAMMALS FROM THE STUDY AREA

Species	Dry	Wet	Total	Relative abundance (%)
S. albipes	62(29)	80(34)	142(63)	69.95
S. griseicauda	15(5)	13(5)	28(10)	13.79
M. natalensis	8(2)	6(2)	14(4)	6.9
L. flavopunctatus	4(1)	2(2)	6(3)	2.96
L. chrysopus	1(1)	3(1)	4(2)	1.97
M. mahomet	2(0)	2(1)	4(1)	1.97
R. rattus	1(0)	2(1)	3(1)	1.48
A. abyssinicus	1(2)	1(0)	2(2)	0.98
Total	94(40)	109(46)	203(86)	100

The number of individuals captured during the wet season was higher than the dry season (Table 3). However, the seasonal variation in capture rate was not statistically significant (χ^2=1.11, df = 1, P>0.05).

From the trapped mammal species, *S. albipes* was relatively the most abundant and followed by *S. griseicauda* and the least abundant was *A. abyssinicus*.

A total of 257 individuals of none-trapped mammals belonging to 14 species were recorded from both study sites (Table 4).

TABLE 4
SPECIES COMPOSITION AND RELATIVE ABUNDANCE OF NON-TRAPPED MAMMALS FROM THE STUDY AREA

Species	Dry	Wet	Average	Relative abundance (%)
C. guereza	44	66	55	21.40
R. redunca	56	46	51	19.84
T. s. meneliki	56	42	49	19.07
C. pygerythrus	35	50	43	16.73
T. splendens	25	37	31	12.06
P. anubis	6	12	9	3.50
C. crocuta	2	6	4	1.56
S. grimmia	3	5	4	1.56
C. civetta	3	3	3	1.17
H. cristata	2	2	2	0.78
H. sanguineus	0	4	2	0.78
O. afer	2	1	2	0.78
L. serval	1	1	1	0.39
P. albinucha	1	1	1	0.39
Total	236	276	257	100

Relatively more number of individuals was observed during the wet season than the dry season. However, *R. redunca* and *T. s. meneliki* were recorded more during the dry season. Among the species observed, the most abundant was *C. guereza* (21.40%) followed by *R. redunca* (19.84%), *T. s. meneliki* (19.07%) and *C. pygerythrus* (16.73%) whereas *L. serval* (0.38%) and *P. albinucha* (0.38%) were the least abundant (Table 4).

A total of five different habitats such as grassland, bushland, shrubby woodland, plantation with secondary growth and thick forest canopy were surveyed (Table 5).

The species composition and abundance varied among different habitats. The variation in species composition among habitats was not statistically significant (χ^2=0.79, df = 4, P>0.05). More than 108 (23%) individuals belonging to 13 species were recorded from thick canopy forest followed by bushland (12) (Table 5). The number of individuals trapped from bushland habitat was 99 (21.52%). The abundance of mammals recorded in the grassland, shrubby woodland and plantation habitats were 90 (19.57%), 89 (19.35%) and 74(16.09%), respectively. The species composition, distribution, and abundance of small mammals in different habitats are given in Table 5. Only nine species were recorded from grassland habitat. *Stenocephalemys albipes* was recorded from the entire habitat even though it was more abundant in thick canopy forest. The other species were recorded at least from two habitats with the exception of *R. redunca*, *R. rattus* and *A. abyssinicus* recorded only from grassland and *L. serval* and *P. albinucha* from thick canopy forest habitats (Table 5).

TABLE 5
SPECIES COMPOSITION, ABUNDANCE AND DISTRIBUTION OF MAMMALS IN DIFFERENT HABITATS

Species	Habitat types					Total
	Grassland	Bushland	Shrubby woodland	Plantation	Thick canopy forest	
S. albipes	14	26	34	12	56	142
C. guereza	0	15	10	12	18	55
R. redunca	51	0	0	0	0	51
T. s. meneliki	0	13	12	9	15	49
C. pygerythrus	5	10	16	12	0	43
T. splendens	7	13	3	8	0	31
S. griseicauda	0	7	5	10	6	28
M. natalensis	5	3	2	4	0	14
P. anubis	0	6	0	0	3	9
L. flavopunctatus	0	0	4	2	0	6
L. chrysopus	0	3	0	0	1	4
M. mahomet	2	0	0	2	0	4
C. crocuta	0	0	0	2	2	4
S. grimmia	1	0	1	1	1	4
R. rattus	3	0	0	0	0	3
C. civetta	0	1	0	0	2	3
A. abyssinicus	2	0	0	0	0	2
H. cristata	0	1	0	0	1	2
H. sanguineus	0	0	1	0	1	2
O. afer	0	1	1	0	0	2
L. serval	0	0	0	0	1	1
P. albinucha	0	0	0	0	1	1
Total	90	99	89	74	108	460
Percentage (%)	19.57	21.52	19.35	16.09	23.48	100
No. of species	9	12	11	11	13	22

The distribution of mammals varied among species and habitat types. *Stenocephalemys albipes* was the most widespread and abundant species in most habitats. It comprised 30.87% (142) of total recorded species. The other widely distributed species were *C. guereza*, *T. s. meneliki*, *C. pygerythrus*, *T. splendens*, *S. griseicauda*, *M. natalensis* and *S. grimmia*. These were recorded at least from four habitats although their abundance differed from habitat to habitat (Table 5).

The majority of mammals were recorded from the thick canopy forest habitat. However, the plantation with secondary growth habitat was the most diversified habitat with Shannon-Weaver-Index (H') of 2.161 and Simpson's Similarity Index (SI) of 0.8711. The least diversified habitat was the grassland with the smallest Shannon-Weaver-Index (H') of 1.464 and Simpson's Similarity Index (SI) of 0.6402 (Table 6). Dominance index was highest (0.3598) for grassland and least (0.1289) for the plantation habitat. In the same way, evenness index is highest (0.789) for the plantation and least for thick canopy forest habitat (Table 6).

TABLE 6
DIVERSITY INDICES OF MAMMALS IN DIFFERENT HABITATS

Habitat	No. of species	Individuals trapped	Dominance	SI	H'	Evenness
Grassland	9	90	0.3598	0.6402	1.464	0.4802
Bushland	12	99	0.1474	0.8526	2.11	0.6875
Shrubby woodland	11	89	0.2163	0.7837	1.844	0.5747
Plantation	11	74	0.1289	0.8711	2.161	0.789
Thick canopy forest	13	108	0.321	0.679	1.581	0.374

(H' = Shannon-Weaver-Index, SI = Simpson's Similarity Index)

IV. DISCUSSIONS

The study area still contained some remnant natural forest of the type of dry evergreen montane forest type. As stated by Friis and Kew Royal Botanic Gardens [23], the earlier 35–40 % of the country's land area covered with high forest has been gradually reduced to 16% in the 1950s and to 3.1 percent by 1980 and at present less than 2%. Rapid population growth, extensive forest clearing for cultivation, overgrazing and exploitation of forests for fuel wood and construction materials were the main causes of deforestation. The occurrence of fragmented and isolated mature trees in farmlands and the patches of forests seen around church-yards and religious burial grounds indicate the presence of vast area of forest coverage in the past [24]. The current mature tree species composition recorded was comparable with similar studies conducted in different parts of the country [24], [25].

Conservation of biological resource is currently one of the leading agenda for a number of world conservation organizations, authorities and interest groups because of the anthropogenic activities that lead to degradation and depletion [26]. The major mechanisms of forest degradation, habitat change and biodiversity loss are habitat alteration for agriculture, urbanization and human settlement, over exploitation, forest fires and overgrazing [27].

Large numbers of species of mammals including endemics were observed [17]. Species that are endemic to a specific habitat type in the landscape are likely to be excluded from their habitat range [28]. Local extinctions are expected to be negatively correlated with the patch size as well as the amount of habitat in the landscape [29]. Therefore, the more the habitats are destroyed, more species become extinct. Hill [30] reported that the increasing population of wild animals with the expansion of human populations results in competition for resources and conflict with wildlife.

The record of 22 species of mammals belonging to five orders excluding Order Chiroptera from the study area can be used as an indication for large stock of mammalian biodiversity [17]. Since none of the individuals from Order Chiroptera were identified to the species level the order and its species were not included in the list. Contrary to the present result, Seiler [6] indicated that habitat loss reduces species diversity although the exact fragmentation thresholds depend on species' habitat requirements and mobility and the mosaic pattern of habitats in the landscape. McGarigal *et al.* [31] also stated that small remnant habitat patches support fewer individuals with few opportunities for intra-specific interactions but in the present study the opposite was recorded. Although there were many effects of fragmentation on individual behavior, habitat use patterns and intra- and inter-specific interactions, habitat area, edge and isolation effects affect the distribution and abundance of mammals [31]. The record of *P. anubis* and *C. pygerythrus* from only one site might be related with species inter-specific interactions. The case of *R. redunca* is due to the existence of the most suitable grassland habitat. Patchiness in the distribution of resources caused by habitat fragmentation may ultimately affect population viability. Specifically, the subdivision and isolation of populations by fragmentation can lead to reduced dispersal success and patch colonization rates [31].

The variation in species composition and abundance of species of mammals among different habitats is related to the quality of the habitat and preference of the species. In the present study, thick canopy forest habitat had more individuals and species. This was related to suitability and provision of better shelter and cover. However, Shannon-Weaver-Index (H') and Index (SI) indicate that the plantation mixed with natural vegetation of secondary growth habitat was the most diversified habitat. This might be due to the disturbance of habitat with diverse type of natural secondary growth vegetation. The abundance and richness of mammal assemblages considerably differ among remnant fragments [32].

Populations can become isolated within their patches when all of the surrounding habitats are destroyed. Removing these habitats lead to species migration into different adjacent patches. While some species require a single type of habitat to carry out their activities, there are many species that need multiple serial stages to do their activities. If these habitats are not available, or even are separated by barriers from one another, species will be restricted to certain types of habitats and will be at high risk [28]. Olifiers *et al.* [3] indicated that human presence and related activities in areas inhabited by mammal communities produce disturbing effects. The presence of human dwellings near natural habitats influences species composition which is certainly true in the case of *R. rattus* [3].

Most of the recorded mammals except for small mammals require wide home range which should be larger than the existing habitats and were not sufficient and safe. Patchiness in the distribution of resources caused by habitat fragmentation may ultimately affect population viability [31]. In addition, it also results in the subdivision and isolation of populations. It also leads to reduced dispersal success and patch colonization rates which results in a decline in the persistence of local populations and an enhanced probability of regional extinction [31].

V. CONCLUSION AND RECOMMENDATIONS

The major purpose of the study was to develop basic information on the mammal diversity, relative abundance, and distribution in fragmented dry evergreen remnant montane forest habitat. The Child Care Center compound was more intact with remnants of the original forest type than the School of Agriculture. This can be used as an indicator on the extent of the quality and suitability of habitat for mammals and other species. In both compounds, beside the protection of natural forest, there was plantation with indigenous and exotic species. Furthermore, the presence of more number of matured trees show the relatively low level of disturbance. The documentation of 22 species of mammals indicates the existence of high stock of mammalian species. The conservation of mammals and their habitat provides environmental services like climate change mitigation, tourist attraction and income generation, and social and cultural heritage. Moreover, as the surrounding habitat was degraded and defrosted, the existing small remnant natural forest was the only surviving option and refugia for diverse species of mammals. To maintain and conserve the mammals and their habitat with other biodiversity, the current urban expansion and other threatening anthropogenic activities must be managed. The present study can contribute towards understanding of mammal species composition, relative abundance, distribution, and threats such disturbed premises. This has considerable importance in their habitat conservation. Nevertheless, this is a preliminary study and it is recommended that further detailed investigation on the biodiversity must be conducted.

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CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

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