The consequences of habitat loss and fragmentation on the distribution, population size, habitat preferences, feeding and ranging Ecology of grivet monkey (*Cercopithecus aethiopes aethiops)* on the human dominated habitats of north Shoa, Amhara, Ethiopia: A Study of human-grivet monkey conflict

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1. Introduction

World mammals status analysis on global scale shows that primates are the most threatened mammals (Schipper *et al*., 2008) making them indicators for investigating vulnerability to threats. Habitat loss and destruction are often considered to be the most serious threat to many tropical primate populations because of agricultural expansion, livestock grazing, logging, and human settlement (Cowlishaw and Dunbar, 2000). Deforestation and forest fragmentation have marched together with the expansion of agricultural frontiers, resulting in both habitat loss and subdivision of the remaining habitat (Michalski and Peres, 2005). This forest degradation results in reduction in size or fragmentation of the original forest habitat (Fahrig, 2003). Habitat fragmentation is often defined as a process during which "a large expanse of habitat is transformed into a number of smaller patches of smaller total area, isolated from each other by a matrix of habitats unlike the original". Such process can affect the survival of the vulnerable species through a number of different mechanisms including reduction of the total amount of a habitat types and subsequent reduction in quantity and quality of food resources and sleeping trees, genetic deterioration by minimizing gene flow and edge effect which increase predation/disturbance by humans (Anderson *et al*., 2007; Chaves *et al.,* 2012).

Primates are large, charismatic mammals found in many of the world's tropical forests (Fashing *et al*., 2012). There are about 13 species of primates in Ethiopia excluding *Homoe sapiens* (Afework Bekele and Yalden, 2013). Species and subspecies of primates that occur in Ethiopia are black and white colobus monkey *(Colobus guereza),* gelada baboon *(Theropithecus gelada)*, grivet monkey *(Cercopithecus aethiops aethiops),* Hamadryas baboon *(Papio hamadryas)*, olive baboon *(Papio anubis)*, bushbaby or Senegal lesser galago *(Galago senegalensis)* and Somali lesser galago (*Galago gallarum)* (Butynski and de Jong, 2004), Black faced vervet *(Cercopithecus aethiops pygerythrus)*, Bale monkey *(Cercopithecus aethiops djamdjamensis)*, De Brazza's monkey *(Cercopithecus neglectus)*, Patas monkey *(Erythrocebus patas)*, Sykes' Monkey *(Cercopithecus albogularis)* (Kingdon, 1997; Groves, 2005), and two subspecies of blue monkeys (*Cercopithecus mitis boutourlinii and Cercopithecus mitis stuhlmanni*) (Kingdon, 1997; Fairgrieve and Muhumuza, 2003).

Historically, non-human primates shifted their foraging ecology and survived with a new adaptation in a modified habitat. It has been believed that series of environmental changes that transformed tropical forest into savannah woodlands (Reed and Rector, 2007) made frugivore primates faced longer periods of reduced food abundance and were forced to use alternative sources such as meat, nuts, cereals or underground storage organs of plants (Bunn and Ezzo, 1993). Forest non-human primates are thought to be particularly vulnerable to local extinction in fragmented landscapes (Cowlishaw and Dunbar, 2000). Those of arboreal primates are often unable to cross non-forest areas, which results in low population densities, and are often subjected to direct human persecution (Chiarello and de Melo, 2001). Consequently, species that are unable to adapt to modified habitats are being forced into small, marginal habitat patches. In small and fragmented populations, genetic diversity may be reduced owing to increased levels of drift and inbreeding. This reduced diversity is often associated with decreased fitness and a higher threat of extinction (Bergl *et al*., 2008). As a result, the long term survival of many of these animals is questionable (IUCN, 2000). Tangible examples which end up to extinction

failing to adapt the habitat modifications are the particular habitat specialists like *Theropithecus oswaldi*, *Theropithecus brumpti* and *Theropithecus darti* (Hughes *et al.*, 2008) and Koala lemur *Megaladapis edwardsi.* In recent habitat fragmentation, some researchers argue fragmented habitats are able to sustain species capable of exploiting resources in anthropogenic habitats (Daily *et al*., 2003). This however is controversial and could be critical for habitat specialists which do not have the adaptation for wide range of food types.

Like many other non-human primates and medium to large-sized vertebrates of tropical rain forests, the survival of grivet monkeys, is threatened by hunting and habitat destruction. Crude estimates of the annual loss of natural tropical forest vary widely among countries, but in general it is approximately 0.7% for Africa and this rate appears to be increasing as the remaining area of forest decreases (Struhsaker, 2005). Conflict between people and animals is one of the main threats to the continued survival of many species in different parts of the world, and is also a significant threat to local human populations. As human populations expand and natural habitats shrink, people and animals are increasingly coming into conflict over living space and food. The impacts are huge as people lose their crops, livestock, property, and sometimes their lives. The animals, many of which are already threatened or endangered, are often killed in revenge or to prevent future conflicts. Accordingly, natural resource management is in many ways a form of conflict management (Warner, 2000). Increased competition for natural resources among multiple stakeholders with diverse interests is occurring worldwide within the current trends of globalization. Ecosystems and habitats are fast becoming human dominated, which means that more species, including primates, are forced to exploit new human resources to survive (Strum, 2010).

1.1. Background and justifications

Grivet monkeys *(Cercopithecus aethiops aethiops)* are guenons "any slender agile Old World monkey of the genus *Cercopithecus*, inhabiting wooded regions of Africa and having long hind limbs and tail with long hair surrounding the face." Grivet monkey also referred as the savanna monkey or African green monkey and is the most widely distributed of the guenon species, found almost all across Africa, from Ethiopia to Senegal and from Sudan to South Africa (Shimada and Shotake, 1997). So far, this species is considered to be a widely distributed and often common species in northern and central Ethiopia in an altitude ranging from near sea level to approximately 3000 m a.s.l. (Yalden *et al*., 1977). However, because of habitat fragmentation following expansion of human settlement and cultivated land into previous wildlife habitat the distribution of Grivet monkey is highly challenging nowadays. With regard to habitat use, Grivet monkey occupies a wide range of habitats from riverine and montane forests to savannas, open woodland and forest edges as well as in mangrove swamps, cultivated areas and urban parks (Yalden *et al*., 1977, Fedigan and Fedigan, 1988; Zinner et al., 2002; Getachew Gebeyehu and Afework Bekele, 2009). In many areas, this monkey frequents human settlements and feeds extensively on cultivated plants (Yalden *et al*., 1977), which exacerbate the conflict with humans. Like all other primates, grivets have an evolutionary history of being a tropical species dependant on forests and their rich supply of food types for survival. Although their diet is dominated by plants of secondary growth, grivet monkeys can be regarded as opportunistic omnivores, little specialized (Zinner et al., 2002). Grivet monkey is distinguished from the vervet *(Cercopithecus aethiops pygerythrus)* primarily by differences in fur and skin colour and the

restriction of the later taxon southwards of Ethiopia in altitudes not more than 1500 m a.s.l. (Yalden et al., 1977).

Human Wildlife Conflict (HWC) arises from a range of direct and indirect negative interactions between humans and wildlife. The loss, degradation and fragmentation of habitats through human activities such as, logging, animal husbandry, agricultural expansion and developmental projects (Fernando *et al*., 2005) intensify the conflict. As habitat is fragmented, the length of edge for the interface between humans and wildlife increases, while the animal populations become compressed in limited refuges. Consequently, it leads to greater contact and conflict with humans as wild animals seek to fulfill their nutritional, ecological and behavioural needs (Sukumar, 1990). These can culminate in potential harm to all participants, and lead to negative human attitudes, with a decrease in human appreciation of wildlife and potentially severe detrimental effects for conservation (Nyhus *et al.*, 2000).

A wide range of species are responsible for conflict, with the principal culprits being primates, rodents, ungulates, elephant, lions and leopards (Hill, 2000; Saj *et al*., 2001). Farmers suffer economically from the loss of crops and livestock. There is a general perception that primates living in human modified landscapes or at the edge of reserve boundaries are often agricultural pests and can pose considerable costs to cultivators living in their vicinity (Hill 2002). As human population increases and the demand for resources grows, the frequency and intensity of conflicts between protected areas and local people will increase (Newmark *et al*., 1993). Human-wildlife conflict affects species, particularly large mammals. Due to such conflict, most are either critically endangered or decline.

However, studies of the ecological value of forest-dwelling primates have stressed their roles as potential pollinators, seed dispersers and as plant and seed predators (Estrada, 2006). This reveals the importance of primate survival for continued forest dynamics and existence (Chapman and Onderdonk 1998), and for local human population and economies, especially where humans use the seeds of tree species (Lambert and Garber 1998). Movements and feeding activities of herbivorous monkeys in agroecosystems may result in removal of foliage and in the dislodging of branches and of other organic matter in canopy trees, providing shade to cultivators favoring primary productivity (Estrada, 2006). The foraging activities of insect-eating monkeys such as squirrel monkeys in African palm plantations and of golden-headed lion tamarins in C*abruca cacao* plantations may be important in ameliorating the impact of insect pests (Raboy *et al*. 2004). Defecation by the monkeys may add important nutrients to the soil of the agroecosystems (Estrada, 2006).

Human and wild animals have been in conflict because agricultural crops generally offer a rich food source for wild animals as well as for people. Crop raiding where wild animals move from their natural habitat onto agricultural land to feed on the product that humans grow for their own consumption is one of the major causes of human - wildlife conflict (Ojo *et al*., 2010**)**. Crop damage affects farmers directly through loss of their primary food and cash resources. Crop raiding may cause substantial damage to agricultural crops that compromise local food security (Hill, 2000). Crop raiding also may result increased time spent by humans in protection of the fields and potentially decreased yields per human labor effort. Such conflict usually reduces tolerance of wildlife within neighboring human communities (Sekhar, 1998). The context of crop

raiding must be understood before implementing deterrent interventions including the behavioral ecology of raiding species, crops grown on farms, and extent and frequency of raiding events (Sitati et al., 2005). Farmer's perceptions about crop raiding should be assessed to ensure actions and anticipated outcomes address farmer concerns (Gillingham and Lee, 1999).

Primates are one of the most frequently cited crop pest herbivores (Naughton-Treves, 1998; Hill, 2000). Thus, primates and humans are always in potential conflict over crops due to the renowned crop raiding behaviour of many primate species. The genera *Cercopithicus, Papio* and *Macaca,* particularly baboons and vervet monkeys are some of the most serious crop raiders because of their intelligence, adaptability, wide dietary range, complex social organization and aggression (Sillero-Zubiri and Switzer, 2001). The major threats to primate populations, in most primate range countries, are due to the extensive conversion of primate habitat into areas of human use for agriculture, forestry and plantations, trapping for the biomedical trade, the effects of the bush meat trade and disease (Walsh *et al*., 2003). Even though human herders may not have a perception of monkeys as pests, the indirect competition can drive monkeys into habitats, such as forests or plantations (Ciani *et al*., 2001), where they cause significant damage and become pests.

Farming is the major source of food and income for poor rural households in developing countries, whose numbers are growing despite urbanization and overall economic growth. This suggests escalating conflicts in agricultural landscapes between the conservation of wild biodiversity and the provision of other ecosystem services on which the livelihoods of poor people critically depend (Bolwig *et al*., 2006). These land uses, particularly the presence of settlements and of intensive or semi-intensive crop farming that renders habitats for wild fauna smaller and more fragmented, have a major effect on the distribution and abundance of wildlife (Fritz *et al*., , 2003). Thus, farmland expansion and intensification inevitably leads to a degradation of habitats for most types of fauna through changes such as the reduction in space and food resources, loss of roosting and nesting places, and fragmentation of habitats restricting movement and seed dispersion. At the same time, the new habitats created might not be those to which wild species are naturally adapted (Bolwig *et al*., 2006). As a result, species that are unable to adapt to altered habitats are forced to decrease their number and invade the marginal habitats. In communities with a subsistence economy, even small losses can generate strong negative attitude towards wildlife (Oli *et al*., 1994). Accordingly, the human-Grivet monkey conflict is a baseline research that needs to be conducted to disclose the intensity of conflicts and the attitude and impact of the local people to the distribution, ranging ecology and conservation of grivet monkeys in human dominated habitats.

1.2. Statement of the problem

Recent evaluations have suggested that out of the world's 634 primate species approximately 50 % are threatened with the risk of extinction; most of these are located in tropical regions (IUCN, 2014). Anthropogenic factors, deforestation, commercial bushmeat, hunting, and the illegal animal trade are considered the primary threats to primate conservation. A failure to respond to these threats may provoke the first primate extinctions in over a century. Several intrinsic and extrinsic factors strongly influence primate conservation. Intrinsic aspects affecting primate conservation include primates' low reproductive potential, because most primates produce only one offspring per litter with long inter-birth intervals (Serio-Silva *et al*., 2015). This low

reproductive rate can mean that stochastic or rare events have large impacts on population size and viability. Primates living in poor, developing nations may be affected by economics and human population growth, with increasing extraction of resources from the forest as well as modification or destruction of primates' natural habitat. External factors affecting primate conservation include: hunting for food (spider monkeys in Central and South America), hunting for trophies or ornaments (apes, colobus monkeys), and hunting of pest species (grivet monkeys, macaques, baboons) as a result of conflict over crop raiding (Lee and Priston, 2005; Dickman, 2010; Isabirye-Basuta and Lwanga, 2008). Primates are also 'harvested' for biomedical research as they are considered to be good models for medical research because of their close genetic relationship to humans. Primates are also brought into captivity for the pet trade (Serio-Silva *et al*., 2015).

The most important threat of primate species is mainly associated to human impacts through habitat destruction that has high potential impact not just on primates but on local biodiversity as a whole. Species-specific studies on details of the conservation threats of primates are an important step towards effective conservation management plan. However, compared to other varieties or subspecies of the green monkey, only a few studies have focused on grivets (Fedigan and Fedigan, 1988; Shimada and Shotake, 1997). In large parts of its supposed former range, the current distribution of the species is not clear. Most of the relevant data, for instance Eritrean Grivet monkey, stems from sources older than half century (Yalden *et al*., 1977). Accordingly, information on the status and distribution of grivet monkeys is incomplete and outdated (Zinner *et al*., 2001). Although grivet monkeys are restricted to areas of Sudan, Ethiopia and Eritrea, very few data are available about the current distribution and abundance of this primate taxon for its whole range (Zinner *et al*., 2002). Grivet monkeys were once reported as far north as 19^0 N in the Nile River valley of the Sudan, but during the last 100 years they disappeared from many localities, due to progressive deforestation along the Nile River. The distribution of grivet monkey is little known in Ethiopia (Zinner *et al*., 2002). In addition, the closeness of grivet monkeys to human agricultural activities is a source of constant competition. Therefore, problems of grivet monkeys raiding gardens and crop-fields and the response of humans to this action will be assessed from all the survey areas.

To that end, wildlife population monitoring and inventory of an area is essential from time to time for effective conservation endeavor (Ricklefs and Miller, 2000). Data on the imact of habitat destruction, abundance, density, population size, and behavioural ecology of primates are imperative for developing successful conservation management strategies. Particularly, understanding the basic quantitative natural history of primate species including the activity budget, feeding and ranging ecology is vital to their conservation (Caro, 1998; Fashing, 2007; Mekonnen et al., 2010a). Despite, most other species and subspecies of Ethiopian primates have been subjects of studies for decades, little is known about the conservation status, behaviour, ecology and genetics grivet monkey (Zinner *et al*., 2002). More preciesely, nothing is known on the population trend and behavioural ecology of grivet monkey in north Shoa, central Ethiopia. Accordingly, the research seeks to contribute to the future conservation of Grivet monkey based on the findings concerning their habitats, poplation density, abundance, ecology and pertinent threats.

1.3. Objectives

1.3.1. General Objective

The overall aims of this study is to provide an insight into the impacts of habitat loss and fragmentation on the distribution, Population size, habitat preferences, feeding and ranging Ecology of grivet monkey (*Cercopithecus aethiopes aethiops)* on the human dominated habitats of three Selected Districts in north Shoa Zone, Ethiopia: A Study of human-grivet monkey conflict

1.3.2. Specific Objectives

- To estimate the population status of grivet monkey in the region
- To determine the amount of economic loss due to crop raiding by grivet monkey
- To determine the effect of habitat loss and fragmentation on behavioural ecology of grivet monkey in the study region
- To monitor patterns of habitat preferences and distribution of grivet monkey
- To determine the diet and foraging behavior of grivet monkey
- To examine the ranging ecology and home range use of grivet monkey
- To assess the degree of human-grivet monkey conflict in the region
- To provide a set of basic management actions for the conservation of grivet monkey

1.4. Research hypotheses under investigation

- How is the population status of grivet monkey in the human dominated habitats of shoa?
- In which habitat type does human-grivet monkey conflict more severe? What problems do the local people face with regard to wildlife?
- How is the trend of crop raiding by grivet monkey and other wildlife in the area?
- What is the attitude of the local people towards grivet monkey?
- Which habitat type is more preferred by grivet monkey?
- What plant species do grivet monkeys prefer to consume?

2. Description of the study area

2.1. Location

The study area is located in North Shoa Zonal Administration of Amhara National Regional State on the slopes of the eastern and western escarpment of the northwestern highlands. It lies both east and west of the main road leading from Addis Ababa through Debre Birhan (the capital of North Shoa Zone) to Dessie. The study area encompasses three Districts namely Tarmaber, Basona Worana and Ankober Districts with special emphasis to forest surrounding areas such as Wof-Washa forest, Dense forest and Likmarefia forest, where grivet monkeys are historical occurred. (Fig. 1). Before being cleared for agriculture, it was a dense continuous forest throughout the region, but most land outside protected areas has been deforested and smallholder subsistence agriculture dominates the landscape nowadays.

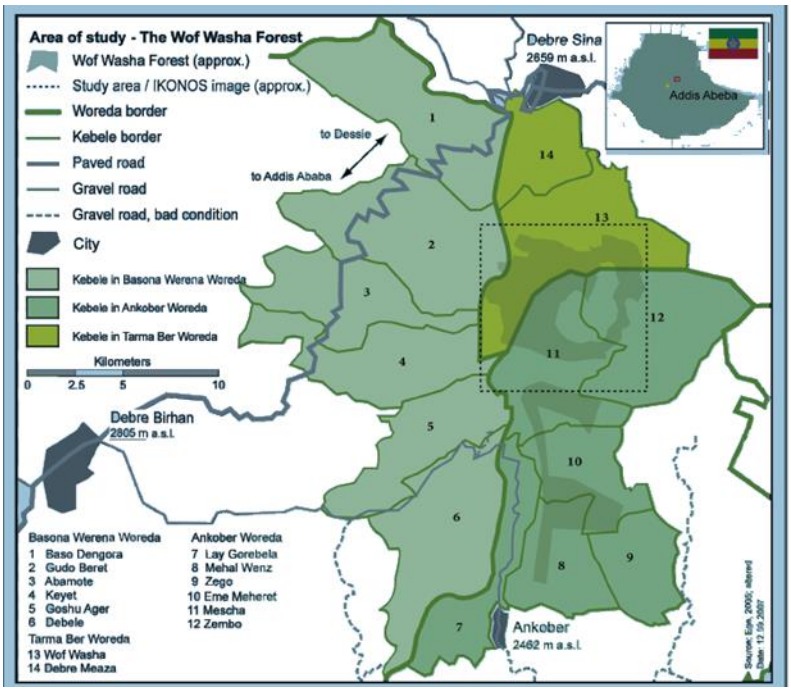

Figure 1. Map of the study area (Source: Ege, 2002)

2.2. Physical and biological settings of the area

2.2.1 Climate

The distribution of rainfall in the area is bimodal, characterized by a prolonged wet season from July to September (big rain) and small rain from March-May with a peak in April. The small rainy season is unpredictable and highly variable. As in many tropical rain forests, there was considerable month-to-month variation in rainfall in the region. The area receives a rainfall of approximately 1400mm per annum coupled with the low evapo-transpiration (IBC, 2003). The study area fall into different climatic zone as Weina Dega, Dega and Wurch. Temperatures range from a minimum of -8°C to 4°C to a maximum of 18°C to 35°C. The mean annual minimum temperature is 10^0C whereas the mean annual maximum temperature is 20^0C.

2.2.2 Geology and Soil

Precambrian rocks that underlie the whole of Ethiopia consist of complex of metamorphic and igneous rocks of many different grades and types. In the central plateau of Ethiopia, Mesozoic rocks mainly of sandstones and limestones, which are overlain by tertiary lava, cover the Precambrian rocks (Mohr, 1971 Cited in Lulekal et al., 2014).

2.2.3 Vegetation

The vegetation of north western highland forests of Ethiopia broadly belongs to the Afromontane archipelago-like center of endemism mostly found in the tropics (White, 1983). According to Friis (1992) and Tamrat Bekele (1993), the Vegetation in north western highland Ethiopia are categorized under the dry evergreen montane forest which is characterized by one or more closed strata of evergreen trees. This dry evergreen vegetation type further divided into two: the Afromontane rainforest which occurs above 2000 m a.s.l. in the tropics and this forest characteristically contain a mixture of *Podocarpus falcatus* and broadleaved species. The second type includes the Transitional Rainforest, which occurs in the north western highlands of Ethiopia. The altitudinal location of the study area reveals that the vegetation under study can be categorized in Afromontane rainforest. The vegetation of the study area is in the category of

Afromontane rainforest, undifferentiated Afromontane rainforest, single dominant Afromontane forest (such as *Juniperus procera* and *Hagenia abyssinica* dominated forest) and dry transitional montane forest. At and above 3,000 m a.s.l *Erica arborea*, *Hypericum revolutum* and giant *Lobelia* spp. are the most dominant species with few *Hagenia abyssinica* as the area is the Ericaceous belt and the alpine belt.

2.2.4 Fauna

In addition to smaller to larger mammal species, the area holds more than 50% of the country's highland biome bird assemblage like the endemic rare and vulnerable Ankober Serin, varieties of venomous snake, and amphibians. Large troops of *Theropithecus gelada* (endemic mammal of high tourist interest due to their looks and behaviour). The endemic Menelik's bushbuck (*Tragelaphus scriptus meneliki*) also found to populate on the forested areas of the region.

3. Methodology

3.1. Habitat stratification, vegetation mapping and Land use cover change

The study area will be classified into homogeneous vegetation units (human settlement, agriculture, forest, bush land and grassland). The habitat types will be classified by using 10 m resolution satellite image. To make the satellite image interpretation and analyses easier, GPS locations from each representative habitat type will be collected randomly and a total of 200 plots with size of 4*5 m^2 area will be allocated randomly across the units except human settlement and agriculture. At lower scale, vegetation sampling will be done to measure the abundance of food items used by the troops within their home range in random samples of 2*3 m^2. The land use cover change in terms of deforestation rate will be estimated from a forest cover during 1990 (From Landsat image with 70 m resolution enough for identifying continuous forest), 2000 (From Landsat image with 30 m resolution) and recent forest cover estimated from 10m spot image by using ERDASS Imagine and Arc GIS 10.3.

3.2. Distribution pattern and population estimate of grivet monkey

Distribution mapping surveys will be conducted in habitats suitable for grivet monkey around potential sites located in the previous studies (Yalden *et al*., 1977). Surveys will be conducted through extensive ground survey which will be supplemented by questionnaire survey using informal interviews of local people from villages familiar with and resides surrounding the sites of grivet occupancy (Iwanaga and Ferrari, 2002; De Jong *et al*., 2008; Gonedele Bi *et al*., 2009) by showing them photographs of the grivet monkey. Whenever grivet monkey is encountered, their group size and age-sex composition, time of observation (time, date and season), GPS location, habitat type in which the monkeys dwell in will be recorded. Moreover, careful descriptions of the observed group/ individuals will be made based on natural markings of individuals for future identification and avoiding double counting. GPS locations recorded during the surveys will be plotted on a map using Garmin Mapsource (6.10.2) and MapInfo Professional 8.0 (De Jong *et al*., 2008) to create a map of the distribution of the grivet monkey in North Shoa and the surrounding areas (Baumgarten, 2006).

Population estimate of grivet monkey will be carried out by transect sampling across its range in the study area (Struhsaker, 1981; Peres, 1999; Buckland *et al*., 2010). A systematic transect will be developed with 400 m difference in the potential range identified from 10 m resolution spot

image. Sighting of the monkeys will be recorded along with its habitat types. Moreover, in heterogeneous habitats, transect lines will be laid in a systematically stratified habitat types and their lengths and widths will be determined according to the habitat types of the study area. When grivet monkeys are encountered, the observer will record the group size, group spread, estimated animal-observer distance, sighting angle, perpendicular distance from the transect to the first animal seen, the height of animal on the tree when first detected (if they are obsereved on tree), and habitat type where the group is spotted (Mekonnen *et al*., 2010b). Both DISTANCE method (Buckland *et al*., 2010; Fashing *et al*., 2012) and animal observer distance method (Mekonnen *et al*., 2010b) will be used for the density estimation of grivet monkey. For accurate density estimates, a total of at least 70 sightings are needed at the study site (Buckland *et al*., 2010; Mekonnen *et al*., 2010b). The distance will be recorded by range finder and angle will be measured by compass. Population density will also be estimated directly by mathematical calculation, as the number of individuals in each group divided by the group's home range size (Fashing and Cords, 2000).

3.3. Behavioural data

Activity Pattern: Intensive behavioural data on the activity budget, habitat preference, feeding ecology and ranging ecology of the study group will be collected using instantaneous scan sampling method on a selected group (Altman, 1974; Lehner, 1996) at 15-minute intervals. Activity budget data from the members of the two focal groups (A and B) will be collected on an average of five consecutive study days each month from each group (Fashing, 2001a; Mekonnen *et al*., 2010a). During the five-day samples, activity scan samples will be collected for up to five minutes duration every 15 min sampling gap between 07:00 to 17:30:00 (Fashing, 2001a). During scan sampling, individuals observed will be recorded as performing one of the following behavioural records: feeding, moving, resting, playing, aggression, grooming, sexual activity, and others such as drinking that do not fit in these categories (Fashing, 2001a; Mekonnen *et al*., 2010a). During each scan, the activity will also be recorded by scanning the group from left to right to avoid possible bias toward eye-catching activities such as grooming, fighting, and mating (Fashing, 2001a). The identity of the scanned individual will be recorded and assigned to one of the following age/sex classes: adult male, adult female, sub-adult male, sub-adult female, juvenile male and juvenile female but not infants (Fashing, 2001a; Harris and Chapman, 2007).
Percent time spent in different activities will be calculated by dividing the proportion of the number of behavioral records for each activity category by the total number of activity records. The behavioural records of the troop will then be used to calculate the activity budgets per day and averaged within each month to construct monthly activity budgets as well as yearly activity budgets for each study group.

Habitat Preferences: When resources are used more than expected based on availability, there is a selection for that resource (Johnson, 1980). Animals select habitats at various scales. Johnson (1980) distinguished four levels of selection from selection of the geographic area to selection of a home-range area, selection of habitat types within the home range. Hence, habitat preference is a function of home-range sizes (Chamberlain *et al*., 2003). As part of habitat selection, an accessible habitat defined by the traditional home range concept which is 100% Minimum Convex polygon (MCP) is used as available habitat. As part of spacing pattern however, MCP is criticized for overestimating the size of home range due to outlying fixes (Harris *et al*., 1990). Accordingly, 95% MCP is used to overcome the limitation by eliminating

the most distant locations. The most intensively used portions of a home range is estimated as core area, where individuals are found with greater probability within the home ranges by 95% kernels estimate (Dahl, 2005) or 50% fixed MCP method (Harris *et al*., 1990).

Habitat preference will be carried out on landscape level and home range level. At landscape level, habitat preference data will be collected by using long transects in the range of grivet monkey for each grivet monkey sightings. At home rang level, habitat preference will be estimated based on observation recorded during the scan sampling. Habitat preference will be carried out based on the number of sightings of grivet monkey from each of the habitat types in both cases. Habitat preferences by grivet monkey in the study area will therefore, be assessed by a combination of transect sampling in different habitat types and instantaneous sampling methods of focal groups (Mekonnen *et al*., 2010b). Encounter rates of groups per km will be calculated for each habitat type (Bobadilla and Ferrari, 2000), and sightings will be summarized as the total number of groups and individuals observed in each habitat type (Anderson *et al*., 2007). Thus each group will be followed and its location and habitat types will be recorded (Gómez-Posada *et al*., 2007; Zhou *et al*., 2013). Then, ArcView 3.2 GIS software will be used to merge the home range and habitat maps to determine the amount of each habitat type in each group range (Gómez-Posada *et al*., 2007). Habitat preferences will be expressed as the percentage of monthly location records occurring in each habitat and the annual habitat pereferences will be obtained by averaging the monthly percentages (Zhou *et al*., 2013).

Feeding ecology: During activity scan sampling, when an grivet monkey is observed feeding, the type of food item as well as the species consumed will be recorded. The type of food items will be recorded as young leaves, mature leaves, root, stem, flower, fruit, seeds, shoot, bark, bud or animal preys. Plant species consumed by individual of grivet monkey will be identified and recorded in the field if known while unidentified species will be collected, named by their local name, pressed and taken to the Addis Ababa University National Herbarium for further taxonomic identification. Observation of consumed plant items at higher canopy layer will be aided by Bushnell binocular.

Dietary composition will be evaluated by determining the proportion of different dietary items and plant species based on the total amount of time spent feeding by focal groups (Mekonnen *et al.*, 2010a). The daily food items and species consumed by the group will be summed within each month to construct a monthly proportion of food items and food species consumed. Diet selection by each study group will be determined from the relative proportions of the number of scans spent feeding on different food items and plant species in the diet. Dietary preference for different food species by the study group will be calculated as the proportion of annual feeding time spent feeding on a certain species i divided by the density of that species i in the study group's home range (Fashing, 2001b; Xiang *et al*., 2007; Mekonnen *et al*., 2010a). Dietary diversity and evenness will also be calculated using the Shannon-Wiener index, H' and the evenness index, J (Krebs, 1999).

Ranging ecology: Ranging data on the two study groups will be collected during two 5 focal full-day follows of each group each month from 07:00 to 17:30 hr (Mekonnen *et al*., 2010a). During instantaneous scan sampling, the location of the geographic center of the study group will be recorded at 15 minute intervals using a Handheld Garmin GPS Map 62stc. The GPS locations

of the group recorded will be used to estimate the average daily distances traveled and the home range utilized by the group each month. The average travel rate will be calculated as average daily distance traveled each month divided by time spent moving. The minimum convex polygon (MCP) and the best home range estimator technique (fixed kernel) methods will be used to determine the home range sizes and daily travel distance via GIS software ArcGIS version 10.0 (Fashing *et al*., 2007; Mekonnen *et al*., 2010a).

3.4. Human Grivet monkey conflict

In order to assess the resource sharing conflict between the two opposing partners questionnaire survey will be administered in about 300 of the households in each grivet monkey localities. These households will be randomly selected by following a pattern of skipping one household, and the second household interviewed. The interviewees will be selected based on chance encounter by the interviewer (Newmark *et al*., 1993). The head of the household will be asked in his presence and any adult member of the individual will be interviewed. A structured self-administered questionnaire survey will be used. All questions will be close ended. Closed ended questions have multiple options and respondents are required to choose one from among these options, where they are directed to the interviewers own set response, whereas open ended questions have no options and respondents are required to answer themselves to express their views freely). Education level of the respondent, when the household established, from which year they face crop riding problem, the stage of the crop grivet start to feed on, how they try to protect grivet monkey from feeding their crop, source of livelihood of the family, their attitude towards grivet monkey and their reasons. Amharic language will be the channel of communication as all of the residents are Amharic speakers.

3.5. Habitat loss and Fragmentation

Habitat destruction derives the rapid decline of a large number of plants and animals in most of the planet's ecosystems (Fahrig, 2003). The loss of natural habitats as well as their fragmentation is exposing wildlife to rapidly emerging challenges, particularly for migratory species and those with large home ranges or 'specific' ecological requirements. Primates, which live in fragmented forests, consume fewer plant species and have greater seasonal differences in diet composition than those living in continuous forests (Boyote *et al.*, 2012).

Deforestation, livestock grazing and agricultural encroachments are becoming common and widespread practices in natural habitats of Shoa. Accordingly, grivet monkeys are currently highly threatened by habitat loss and fragmentation due to abovementioned practices. This study will provide information on how the habitat loss and fragmentation affect the population and behavioural ecology of grivet monkey for the future conservation and management measure. Therefore, habitat loss and fragmentation data will be collected from interviews of the local people and direct observation of the area.

4. Expected output

Information on the impacts of habitat loss and fragmentation on the population status and behavioural ecology of grivet monkey in Ethiopia is lacking. Therefore, this study will provide data on the abundance, density, habitat preference, feeding ecology, activity budget and ranging ecology of Grivet monkeys, which will be essentially helpful to bridge the knowledge gap and to

designing conservation management plan for decision makers for the conservation of this species and other wildlife in the area. A total of three peer-reviewed scientific papers will be published aiming at the international reputable journals. At the end of the project, a copy of the report and results will be given to the funding agencies, relevant local, regional, and federal government and non-governmental agencies to implement the conservation of monkeys. In addition, the result will also be used for increasing the awareness of both the scientific and general public. This dissemination of the results will also help to ensure the participation of the community in conservation of this monkey and its preferred habitats.

5. Challenges of the project

The following major challenges are expected to be encountered during the research work implementation:

- Budget
  - i Transportation; there is no modern public transport to the area and difficult terrain that demand additional cost for mule transportation,
  - ii Field assistants may demand beyond the normal per diem payment,
  - iii The total amount of money that will be allowed may not be sufficient to accomplish all the tasks

- Field equipment
  - i Field equipment may not be avail at required time, so that some sorts of delay or interruption may encountered.

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