ECOLOGICAL STUDIES OF THE AFRICAN CIVET (*CIVETTICTIS CIVETTA*) IN HAWASSA AND WONDO GENET AREAS, SOUTHERN ETHIOPIA

By

Ayalew Berhanu Adem

A Dissertation Submitted to the School of Graduate Studies of the Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Doctor of Philosophy in Zoology (Ecological and Systematic Zoology)

Supervisors

Professor Afework Bekele

Professor Balakrishnan, M.

June 23, 2015

Declaration

I, Ayalew Berhanu Adem, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis. The material contained in this thesis has not previously been submitted for a degree at Addis Ababa University or any other university

The African civet (*Civettictis civetta* Schreber, 1776)

Dedicated to my parents

Almaz Abebo (mam)

Berhanu Odamo (dad)

ACKNOWLEDGEMENTS

First of all, I would like to express my deepest gratitude and appreciation to my supervisors, Professor Afework Bekele and Professor M. Balakrishnan for their encouragement, constructive criticism, consistent guidance starting from the proposal design up to the final version of this thesis, provision of reference materials and equipment for field work, and for their enthusiastic advice for the accomplishment of this research work.

I am also grateful to Dr. Gurja Belay, former Chairman of the Department of Biology, for his kind support during the beginning of my PhD study in the department and his follow up and continuous moral support. I would like to forward my appreciation to Dr. Abebe Getahun, Chairman, Department of Zoological Sciences, for his valuable encouragement and facilitating official works and release of departmental fund. Also secretaries of the department (especially Meseret Amaha) are highly acknowledged for their cooperation. I would also like to thank the School of Graduate Studies, Addis Ababa University for admitting me for my Ph.D. program and for providing research fund.

My sincere gratitude also goes to Wollo University for sponsoring my Ph.D. and paying my salary timely and for provision of fund for the thesis work. Ministry of Education, Federal Republic of Ethiopia, is also acknowledged for sponsoring my study in Addis Ababa University. Animal Biodiversity Thematic Research Project, AAU, is highly acknowledged for covering most part of my research expense. I appreciate and thank Dr. Laura Marker and staff members in Cheetah Conservation Fund (CCF), Namibia for providing a short-term training.

I thank officials of Hawassa University; especially Dr. Yosef Mamo for allowing library and internet services, Ato Addisu Bole for providing equipment and allowing me to use internet in his office, Ato Tadele Zewde for providing GPS, Ato Mengistab Matiwos for arranging laboratory, Ms. Woinshet Afework for assisting during laboratory works and Ato Solomon Shiferaw for his kind hospitability during my stay in the field.

I would like to thank all PhD students of the Department of Zoological Sciences, especially, my colleague Bekele Tsegaye and Araya G/Sillasie, for their valuable encouragement and information sharing in the research work. I thank Ato Fetene and Ms. Roman of the Ethiopian Wildlife Conservation Authority for allowing me to use their library.

I thank my dear brother, Dawit Kechine for his invaluable support by providing me his CDMA internet modem with free internet access for the last three years and also for his financial support. My brothers, Mulugeta Ayele and Kassahun Anshiso are highly appreciated for their assistance during my field work.

Finally, I wish to express my respect, appreciation and thanks to my beloved parents, brothers, sisters, families and people of Wondo Genet for their encouragement and advice. Specially, I would like to thank my dear father, Ato Berhanu Odamo and my mother, Almaz Abebo for their love, commitment, encouragement, advice, moral and financial support from the very beginning of my education. I want to forward my deepest gratitude to my sisters (Nigist Berhanu and Hagere Berhanu) and brothers (Tekle Berhanu and Sebsibe Berhanu) for thier moral and financial support. Commitment, encouragement, endurance and lovely support of my dear wife, Nigat Anshiso, is highly appreciated. Also, I would like to thank her for keeping and caring our children in the absence of me! My daughter, Honey and my son Nathan are highly appreciated for their love and patience, even in my absence. Above all, I would like to thank God, who helped me in all aspect of my study.

Table of Contents **Pages**

ACKNOWELEDGEMENTS …………………………………………………………………….. iv

TABLE OF CONTENTS....………..……………………………………………………… vi

LIST OF FIGURES ……………………………………………………………………… viii

LIST OF TABLES ……………………………………………………………………….. xii

ABSTRACT ……………………………………………………………………………... xiii

1. INTRODUCTION AND LITERATURE REVIEW …………..……………………………. 1

1.1. Introduction ……………………………………………..…………………….. 1

1.2. Literature review ………………………….…………………………………… 4

1.2.1. Taxonomy ……………………………..………………………………….. 4

1.2.2. Biology and ecology of the African civet …..………………………………….. 6

1.2.3. Threats to civets ………………………….…………………………….. 18

1.2.4. Economic importance of African civets ………..………………………………. 20

1.2.5. Civiculture in Ethiopia …………………………..…………………………… 22

1.3. Objectives ………………………………………………..…………………..... 27

1.3.1. General objective …………………………………….……………………. 27

1.3.2. Specific objectives ……………………………………..…………………... 27

2. STUDY AREAS AND METHODS ……………………………..…………………….. 29

2.1. Study Areas ……………………………………..…………….………………… 29

2.2. Methods ……………….……………………………………………………………. 38

2.3. Data analyses ……………………………………………………………………….. 43

3. RESULTS ……………………………………………………………………………… 48

3.1. Civetry ………………………………………………………………………………. 48

3.2. Civet population …………………………………………………………………….. 53

3.3. Feeding ecology of civets ………………………………………………………... 63

3.4. Scent marking ………………………………………………………………… 91

4. DISCUSSION …………………………………………………………………………….. 108

4.1. Civetry ……………………………………………………………………………… 108

4.2. Feeding ecology of civets ……………………………………………………….. 113

4.3. Seed dispersal ………………………………………………………………………. 123

4.4. Scent marking ………………………………………………………………………. 127

5. CONCLUSION AND RECOMMENDATIONS ……………………………………………. 131

5.1. Conclusion ……………………………………………………………………….. 131

5.2. Recommendations ……………….………………………………………….………. 132

6. REFERENCES ……………………………………………………………………………. 134

List of Figures **Pages**

Figure 1. Opening of the perineal gland of the African civet with the white and elongated hairs surrounding the opening ……………………………………………………...…………8

Figure 2. The current distribution range of the African civet ……………….……………………9

Figure 3. A road kill of African civet on the Shashemene to Hawassa road …………………... 20

Figure 4. Map showing the locations of the current study areas in Ethiopia ……………………29

Figure 5. Rainfall and temperature patterns of the lower catchment area …………………..… 31

Figure 6. Trees of *Ficus* sp. (the bigger stem) and *Dracaena steudneri* ……………………….34

Figure 7. Rainfall and temperature patterns of the study sites in the upper catchment area ...….36

Figure 8. Distribution of civetries in the present study area ….………………..………………..48

Figure 9. Age of civetries in the study area as revealed from the local people and the researcher ………...…………………..…………………………………………….. 49

Figure 10. Proportion of civetry distance from the nearest wildlife track …..…………………..50

Figure 11. Multiple clumps of dung pile in the same civetry in one of the civetries located in sugarcane farm …………………...…………………..…………..……51

Figure 12. Number of civets per civetry between different habitats and seasons ……………….57

Figure 13. Mean number of civets that used civetries during wet and dry seasons …………..…58

Figure 14. Density of civets in different habitats during the wet and dry seasons ……………...62

Figure 15. Food items identified from the scats of civets in the commercial farm area ………...73

Figure 16. Diet composition of civets from the commercial farm during the wet and dry seasons …….…………………………………………………………………74

Figure 17. Proportion of each group of food items in the diet of civets in the farmland habitat ……………………...……………………………………………………...75

Figure 18. Food items identified from civets diet during wet and dry seasons in the farmland habitat ……………………..……………………………………………...78

Figure19. Proportion of each of the food items in the diet of civets during the wet and dry seasons in the natural forest …...….……………………………………………81

Figure 20. Proportion of each group of food items recorded in the diet of civets in the natural forest habitat ……………………………………………………..….82

Figure 21. Category of food items recorded in the diet of civets in urban habitat …………….. 84

Figure 22. Food items identified in the scats of civets in urban areas during wet and dry seasons …..………………………………………………….……………85

Figure 23. Seeds and fruits of *P. guajava* seen in one of the civetries ……………………….….. 86

Figure 24. Bulk density of sample soils taken from civetry and non-civetry locations ……...….88

Figure 25. Moisture content of soil samples taken from civetry and non-civetry locations……. 89

Figure 26. Organic carbon content in the civetry and non-civetry soils…………………………90

Figure 27. Organic matter content between civetry and non-civetry soils ………………...……90

Figure 29. pH of samples of soils from civetry and non-civetry sites …………………...……...91

Figure 29. Distribution of scent marked objects around civetry in farmland area ……..……….93

Figure 30. Direction of scent marks on environmental sign-posts of the African civets in farmland habitat …..……………………………….………………….94

Figure 31. Height of scent marked objects from the ground where the scent marks were located ……………………………………..……………………………...…..95

Figure 32. Proportion of color of the perineal glandular secretion on the environmental sign-posts in farmland habitat ……………………...…………………………………..96

Figure 33. Scent remarking by the African civet after removal of the marked scent from the sign-posts …..………………………………………………………………97

Figure 34. Mean weight of the collected perineal glandular secretion of civets during different sessions of remarking …..…………………………………………….97

Figure 35. Distribution of scent marked objects around civetry and along pathways in natural forest habitat ……..……………………………………………….98

Figure 36. Direction of scent marks on sign-posts of the African civets in natural forest area …..……………………………………...…………………..…………….99

Figure 37. Mean weight of perineal glandular secretion of civets weighed at different session of remarking in natural forest area ..…………………………….101

Figure 38. Scent remarking by the African civet after removal of the marked scents from scent-marked objects in natural forest area …...……………………….102

Figure 39. Distribution of scent marked objects around civetry and pathways in urban habitat …..……………………………………………………………...103

Figure 40. Proportion of directions of scents on the sign-posts in relation with pathway and civetry directions in the urban area …………………………………104

Figure 41. Height of scent-marked objects in the urban area …………….…………………105

Figure 42. Remarking of perineal glandular secretion of the African civet after removal of scent from sign-posts in the urban area …….……………………………106

Figure 43. Mean weight of scent on the scent-marked objects measured at different remarking sessions in the urban habitat …..……………………………………….107

Figure 44. Movement of consumed seeds or parts of plants across the available habitats…….125

List of Tables **Pages**

Table 1. Number of civets using each civetry in different habitats and seasons ……...………...54

Table 2. Estimated population size of the African civets in the study area ………...………….. 59

Table 3. Estimated population density of the African civet in the study area ……..……………61

Table 4. Food items of civet identified from the current study area ……………………………65

Table 5. Seasonal food composition and selection by civets in the study area …………..……70

Table 6. Various seeds of plants that germinated on civetries across the four study areas ……..87

Table 7. Number of scent marked sign-posts across the study area ………………..………..92

ABSTRACT

Ecological studies of the African civet (*Civetticits civetta*) was carried out in Hawassa and Wondo Genet areas of Ethiopia, during July 2012 – March 2014. Civetry distribution and density, population density, diet analysis, seed dispersal and scent marking of civets were investigated. Civetries were distributed along pathways at various locations like forest, plantation, bushy area, grassland, farmland, open area, bare land, lake shore and home garden. Higher density of civetries were recorded in the farmland than in other areas ($t = 5.6$, $df = 3$, $p < 0.05$). A population density of 2.3−12.8 civets/km^2 was estimated. Civets feed fruits (36.9%), leaves and shoots (18.3%), roots and tubers (3.4%), invertebrates (19.1%), mammals (13.3%), birds (6.6%) and fish (2.8%) in the present study area. Fruits were the most preferred food item in all habitats. African civet is an effective seed dispersal agent. Over 70% of scent marked sign-posts were distributed around civetries in the farmland and natural forest areas, while about 35% of the scent marked sign-pots were distributed around civetries in the urban area. Most of the scent marked sign-posts were located at or close distance (< 2 m) to wildlife tracks. The amount of scent marks on sign-posts ranged between 0.0001−1.5110 g. The effect of season and habitat on population density and diet composition was insignificant in the present study area due to the habitat variability and modification. Fruit eating behavior of civets and widespread civetries distribution along various habitats have an important role in seed dispersal and implication for conservation of civets.

Key words: African civet, musk, civetry, civiculture, feeding ecology, scent marking, seed dispersal

1. INTRODUCTION AND LITERATURE REVIEW

1.1. Introduction

Ethiopia is a biodiversity rich nation. It is home of more than 300 species of mammals (Afework Bekele and Yalden, 2013). Rodent and bats are the most abundant groups with 40% and 20% of the species, respectively, of all mammals in Ethiopia. There are 31 carnivore species in Ethiopia, which form 11% of the mammalian species in the country. Among them, the Ethiopian wolf (*Canis simensis*) is the most endangered in the world (Marino and Sillero-Zubiri, 2013).

The family Viverridae consists of 35 species of small to medium sized mammals of the world (Nowak, 1999). There are four species of viverrids in Ethiopia, representing 13% of the carnivores in the country. This family consists of mostly omnivorous tropical forest dwelling mammals that are often the most numerous members of mammalian rainforest predator communities in Asia and Africa (Rabinowitz, 1991; Colon, 2002). The African civet (*Civettictis civetta* Schreber, 1776) is the only species of the Genus *Civettictis* (Ray, 1995). It is the largest representative of the African viverrids (Kingdon, 1997). Morphologically, they resemble to genets and linsangs (Kingdon, 1977). They are not true cats, but they look like a member of the cat family. One can easily distinguish African civets by their disproportionately larger hindquarter, low-headed stance and erectile dorsal crest (Ray, 1995). They have different patterns of coat coloration from place to place. The body weight also show variation from region to region, and slightly between sexes.

African civets exist in a wide range of habitats (Ray *et al*., 2008). They inhabit forest, savanna, forest edges, dry areas along water course, farmlands, human settlements and in urban areas (Ray, 1995; Ray *et al*., 2008; Dagnachew Melese *et al*., 2014). This adaptability of the species helps them to distribute along a wide geographical ranges in Africa such as from Senegal and Mauritania to southern Sudan, Ethiopia, Djibouti, southern Somalia and north-eastern Namibia, north and east Botswana and north-eastern South Africa (Ray, 1995; Kock *et al*., 2000). It also exists in islands such as in Zanzibar (Kingdon, 1997). No clear evidence of population dynamics is available to visualize the population trend of this species, even though it is considered as common. It is listed as "Least Concern" by IUCN, and it has a wide distribution range (Ray *et al*., 2008).

African civets are omnivorous and opportunistic foragers. They feed on a wide variety of food items like plants, rodents, birds, insects, carrion, snails, centipede and millipede. Even they are adapted to eat foods, which are toxic to other mammals such as fruits of *Strychnos* sp. and highly decayed carrion. African civets as carnivores indicate the ecosystem health and integrity. They play a major role in maintaining the structure of food-web and community of lower trophic levels in the ecosystem they occupy (Palomares *et al*., 1995). Their frugivorous behavior might influence the dynamics of forest, and shape plant community structure through seed dispersal and regeneration (Mudappa *et al*., 2010). As an ecosystem service provider, civets have a role in facilitating soil fertility due to the behavior of civetry formation. They are good seed dispersers and hence may affect plant community, genetic diversity and heterogeneity of the habitat. Communities of small mammals and insects may be regulated by civets as they feed on these animals.

African civets defecate in a communal latrine site called "civetry". They use a single location for defecation for a long period. Civetries may play roles in territoriality, sexual attraction, warning and defense behaviors. The civetry also provide information regarding diet composition of civets and its seasonality (Bekele Tsegaye *et al*., 2008b), scent communication (Espírito-Santo *et al*., 2007; Bekele Tsegaye *et al*., 2008a), population size (Solberg *et al*., 2005) and their potential for seed dispersal (Russo *et al*., 2006).

They are solitary animals, except during the breeding period, when they may form groups of two or more for a brief period of time. They use olfactory signals as a major means of communication between conspecfics (Ray, 1995; Bekele Tsegaye *et al*., 2008a). They have perineal scent producing glands as a deep pouch at the ano-genital region, anatomically divided into sacs in which the secretion is stored. They produce chemical signals from this glands and mark environmental objects in their home ranges. These marks can stay for a long period in their habitat.

African civet has social, cultural and economical importance in Ethiopia (Yilma Delellegn, 2003). Civiculture (civet farming) play a significant role in the economic history of Ethiopia, especially in the 18th and 19th century. The perineal gland secretion (musk) extracted from the civet was exported to various countries, and even it served as a currency in the past (Woodford, 1990). Civet musk of the African civet and small Indian civet is used in perfume industry, traditional medicine and to flavor tobacco (Xavier, 1994a,b). Currently, civet farming is practiced as a means of income in many parts of Ethiopia (EWCO, 1999). But, the gain from the business to farmers is becoming low due to several factors such as the production of 'synthetic musk', black market, adulteration and abuse by middlemen (Yilma Delellegn, 2003). At present, the practice of the Ethiopian civiculture is not promising, backward and the people in the business are highly secretive and not ready for improvements in farming and husbandry practices

(Tadesse Habtamu, 2014). Animal abuse is also reported in this business (Pugh, 1998). As a result, the World Society for the Protection of Animals urged the fragrance industry and consumers not to buy natural civet musk from Ethiopia (Pugh, 1998).

Despite their diversity, scientific and ecological importance and their long association with man, viverrids remain the least known of all the carnivores (Schreiber *et al*., 1989) due largely to the lack of scientific material available and the difficulties of studying them in the field. Most researches focus mainly on charismatic, endemic, endangered and diurnal species due to the ease of investigation, availability of funds, and due to economic and social values. As a result, some ecologically and phylogenetically important species are not part of many research programs. Civets provide evidence for evolutionary investigation of modern carnivore history. Most of its primitive characteristics help to track back the evolutionary history of larger extant carnivores. Other important ecological aspect of civets is the ability to exist in wide range of habitats, even in highly degraded or fragmented landscapes and urban areas. This adaptability is important in the process of replacing the lost forest in new habitats by seed dispersal. Even the population trend of the African civet is unknown, though it exists in various zoos and in captivity since the pre-historic times.

1.2. Literature review

1.2.1. Taxonomy

African civet is classified under the Class Mammalia, Order Carnivora, Family Viverridae and Subfamily Viverrinae. The Family Viverridae consists of 20 Genera with 35 species (Nowak, 1999). However, as the recent classification of Wozencraft (2005), this Family consists of 15 Genara with 38 species. Viverridae is one of the most diverse groups of the Order Carnivora. It includes civets, fossas, genets and linsangs. Wozencraft (2005) classified Viverridae into four Subfamilies. These are Hemigalinae, Paradoxurinae, Prionodontinae and Viverrinae. The Asian palm civets (Hemigalinae and Paradoxurinae) are confined to South and South-east Asia, whereas Viverrinae is distributed across Asia, Africa and part of Europe (common genets). The Asian linsang (Prionodontinae) is distributed across Asia. Molecular studies have shown that Prionodontinae (Prionodon) is a sister group of the Family Felidae, and should now be erected as a Family (Prionodontidae) (Gaubert and Veron, 2003; Gaubert *et al*., 2005). Based on molecular studies, Gaubert and Cordeiro-Estrela (2006) have argued that the Subfamily Viverrinae should be split into two subfamilies namely Viverrinae (terrestrial civets) and Genettinae (*Genetta* and *Poiana*).

Some authors have categorized African civets under the genus *Viverra* (Rowe-Rowe, 1978); but, Ewer (1973), Rossevear (1974), Kingdon (1977) and Ray (1995) have described it under a distinct Genus, *Civettictis* as the only member of the genus (Ray, 1995). The African civet is named as *Civettictis civetta* Schreber, 1776. There are five subspecies of *Civettictis civetta* (Ray, 1995). These are *C. c. australis* Lundholm, 1955, *C. c. civetta* Schreber, 1776, *C. c. congica* Cabrera, 1929, *C. c. schwarzi* Cabrera, 1929 and *C. c. volkmanni* Lundholm, 1955. Kock *et al*. (2000) reported a sixth subspecies, *viz*. *C. c. pauli* Kock, Künzel and Rayaleh, 2000 from Djibouti. However, there is doubt in the taxonomic validity of this subspecies because of the great variation in coloration exhibited by individuals living in sympatry. Chromosome number of the African civet is 2n = 38.

1.2.2. Biology and ecology of the African civet

Morphologically, African civets have close resemblance to genets and linsangs (Kingdon, 1977). Due to their long body and bushy tail, they look like a member of the cat family. However, they are not true cats. They have a head and body length of 68−89 cm with a tail length of 44.5−46.3 cm and a body weight of 7−20 kg (Kingdon, 1977). There are variations in the average body mass of the African civets from different geographical locations (Ray, 1995). Heaviest civets are located in the western part of Africa with an average weight of 14−15 kg (Rosevear, 1974). African civets in southern Africa have relatively smaller average body mass of 11.2 kg as recoded from Zimbabwe (Smithers and Wilson, 1979). They have an average weight of 12 kg in east Africa including Ethiopia (Kingdon, 1977). Slight variation in the weight was recorded between male and female civets. In the wild, females overweigh males (Smithers and Wilson, 1979); while in captivity males overweigh females (Ewer and Wemmer, 1974). They are the largest among the African viverrids (Kingdon, 1997).

African civets have a high centre of gravity, and the tail serves as a balance, which is kept low and horizontal during movements (Taylor, 1970). African civet looks relatively short-legged compared to its size (Kingdon, 1977). It has a short and strong neck, a pointed muzzle, small eyes, and small rounded ears (Wozencraft, 1984; Skinner and Smithers, 1990). Its tail is bushy, laterally flattened and pointed at the end (Rosevear, 1974).

The coat color of the African civet varies with the location and habitat where they live. The arrangement of markings is highly variable and no two individuals have the same patterns (Ray, 1995). They usually have a color of near white to creamy yellow to reddish buff background with dark spots and a thick strip running down to the back. This dark and camouflaged coat allows the animal to move around freely even in large open terrains including farmlands without being easily noticed by humans (Kingdon, 1977). The black and white head, with black eyes, white lips, banded ears and stripes around the neck are unique. The facial masks and striped neck appear to be convergent with that of the American raccoon (Kingdon, 1977). Nocturnal behavior and dark eye patches are indications that the animal is very sensitive to light. The black patches surrounding their eyes serve as an area where any source of light can be absorbed to protect their eyes (Ortolani, 1999). They have long and coarse hair, which is very thick on the tail (Stuart and Stuart, 2000). African civets have four long non-retractable claws on each paw and the fifth is placed little elevated at the back, so it is not visible in the footprint (Ray, 1995).

The perineal glands are conspicuous among civets and are seen externally as an enlarged pouch. It is covered with whitish hairs and has lips to open and close the pouch (Fig. 1) (Kingdon, 1997). Anatomically, this pouch is divided into several sacs in which the glandular secretion is stored. The gland has two lobes each possess an orifice in the inner faces and the orifice connects with the sacs that store the secretion, commercially known as ‘civet’ or ‘civet musk’.

The skull of the African civet is the longest of any viverrid and heavily-built (Wozencraft, 1984). They have robust and outward projected zygomatic arch. The sagittal and occipital crests are moderate to well-developed. The sagittal crest tends to be more pronounced in males than in females (Wozencraft, 1984). The postorbital processes are usually broad and blunt. The degree of postorbital constriction varies. The interorbital constriction is generally slight, while the paroccipital process is always noticeable and extends beyond the bullae. The coronoid processes of the mandible are high and strong. The auditory bullae are long and ovoid.

Figure 1. Opening of the perineal gland of the African civet with the white and elongated hairs surrounding the opening

Viverrids occur in Africa and Asia except one species, the common genet (*Genetta genetta*), which also occurs in Europe. It is expected that this genet may have been introduced to Europe during historical times. The adaptability of the African civet helps them to occupy a wide range of area of different habitat types. They are abundant in lowlands and in montane forests and around farms, villages, marshes, grassy savannas, reed beds and cane breaks. They also occur in arid areas where there is sufficient cover along drainage lines. They are not reported from Sahara, Somalia and South-West Africa (Skinners and Smithers, 1990).

The African civet and the common genet are among the most widely distributed viverrids in Africa (Do Linh San *et al*., 2013). African civet occurs in 37 countries in Africa that ranges throughout sub-Saharan Africa (Fig. 2). It is a native to the Ethiopian biogeographic region, which includes Angola, Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Congo, Côte d'Ivoire, Djibouti, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Malawi, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia and Zimbabwe (Ray *et al*., 2008).

Figure 2. The current distribution range of the African civet (dark colored areas indicate the range)

Distribution ranges in Africa from Senegal and Mauritania to southern Sudan, Ethiopia, Djibouti, southern Somalia and north-eastern Namibia, north and east Botswana and north-eastern South Africa (Ray, 1995; Kock *et al*., 2000). African civets are present on the islands of Zanzibar, but absent in other islands, such as Madagascar (Kingdon, 1977; Skinner and Smithers, 1990). It is distributed up to 5,000 m asl. on Mount Kilimanjaro (Moreau, 1944 as cited in Ray *et al*., 2008).

African viverrids occupy the majority of small carnivore habitats, both arboreal and terrestrial. The African civet lives in forest and in open habitats. In open habitats, they require a covering of thickets to get safety during resting time (Kingdon, 1997). They also inhabit cultivated and marshy areas. In dry areas, they prefer habitats with dense cover growth along watercourses and around rocky outcrops. They are not adapted to live on tree, as the morphology of their feet is not suitable for climbing. African civets also live near human settlements, and may attack dogs and chicken (Ray *et al*., 2005). They are able to persist in human modified habitats, provided cover is available (Ray *et al*., 2005). Such habitats often favor rodents and arthropods or provide alternate food sources such as fruits (Ray *et al*., 2005). They are uncommon in mature interior forest habitats (Grubb *et al*., 1998). But, they will infiltrate deep forest through logging roads (Ray and Sunquist, 2001). In forests of West and Central Africa, they thrive in degraded and deforested areas (Ray *et al*., 2008).

African civets are omnivorous and opportunistic foragers. They feed on a wide variety of food items like carrion, rodents, birds, centipedes, millipedes, insects, eggs, reptiles, fruits and vegetables (Kingdon, 1997; Wondmagegne Daniel, 2006; Ayalew Berhanu, 2007; Bekele Tsegaye *et al*., 2008b). Eighty percent of the stomach contents of the African civet contained remains of wild fruits, carrion and rodents as reported from South Africa (Bothma, 1971). Insects also constitute significant proportion of their diet (Smithers and Wilson, 1979). Grasshopper, crickets, termites, beetles and stick insects were among the most common insects in the diet of civets. They also prey on aquatic animals such as crabs, snails and mudskippers (Kingdon, 1977). In Ethiopia, the diet of civets is mainly composed of wild and commercial fruits. In addition to these items, they depend on a variety of food items based on seasonal availability in the area. They feed on bony materials, but it might not be digested (Wondmagegne Daniel, 2006; Ayalew Berhanu, 2007; Bekele Tsegaye *et al*., 2008b). However, undigested bony materials were not seen in the scats of the small Indian civet (Sreedevi, 2001). They also feed on food items, which are poisonous to most mammals including fruits of *Strychnos*, and highly decayed carrion (Kingdon, 1997).

Civets have an irregular habit of feeding. They feed large amounts of food when available (up to 2 kg of food in a single night), and in the absence of food, they can stay up to two weeks without food (Kingdon, 1977). They are nocturnal in habit and use their acute senses of smell and hearing to locate their prey. Unlike genets, civets do not chase prey. They grab from their hiding places. During prey capture, they use their teeth to bite and shake the prey violently to break the spinal column or may bite the prey and throw it vigorously (Kingdon, 1997). When the prey animal is dead, they scarf down the food with little chewing in a very short period of time (Estes, 1991). This enables them to eat quickly and keep moving to escape from predators. Due to lack of shearing carnassials, efficiency of meat cutting in the species is low. Hence, they swallow the food with minimal chewing.

Feeding habits of civets can be affected spatially and temporally, depending upon the type of habitats where they live. Studies in three different parts of Ethiopia have revealed variations in the diet composition, seasonality and preference of food items of civets. In Wondo Genet, where the habitat is heterogeneous, they feed on a wide variety of food items with only slight seasonal variations (Ayalew Berhanu, 2007). In this area, the main diet of civet is fruits (commercial and wild). Caracas feeding habit was also reported. In Jimma forest and Menagesha-Suba State Forest, the diet of civets showed significant seasonal variations (Wondmagegne Daniel, 2006; Bekele Tsegaye *et al*., 2008b). In both these areas, civets depend up on fruits for survival. Civets mainly feed on millipede/centipede, insects and vertebrates in Menagesha-Suba State Forest during the dry season, where as the wet season diet was mainly fruits of *Olea* sp. and *Ficus* sp. As opportunistic omnivores, civets supplement their diet with human food wastes from garbage bins, picnic areas and human settlements (Bekele Tsegaye, 2006).

Civetry sites are not only used as a site of defecation; they may also have roles in communication, territoriality, warning and defense behaviors (Bearder and Randall, 1978; Jordan *et al*., 2007) and regulation of physiological functions (Espírito-Santo *et al*., 2007; Barja *et al*., 2011). Using same place to defecate also benefits the animal to centralize waste and cut down on parasites and infection (Lamoot *et al*., 2004). Ecologists also get information regarding the diet composition (Bekele Tsegaye *et al*., 2008b), scent communication (Espírito-Santo *et al*., 2007; Bekele Tsegaye *et al*., 2008a), population size (Solberg *et al*., 2005), mechanism of seed dispersal (Russo *et al*., 2006) and evolution of plant community (Fiorelli *et al*., 2013). Behavior of animals to use communal latrine is not restricted to extant mammals. Recent archeological research on coprolite (fossil feces) indicated the use of communal latrines in Triassic megaherbivores before 220 Mya (Fiorelli *et al*., 2013).

In contemporary ecological research, feces of wild animals collected from latrine sites are used as a resource for genetic variability analysis within and between populations, gene distribution, gene frequencies, individual identification (Schwartz *et al*., 2007) and phylogeographical studies (Beebee and Rowe, 2005). Latrine site selection and defecation behavior of frugivorous animals have impacts on the genetic structure and heterogeneity of plant community in a given habitat through seed dispersal (Mudappa *et al*., 2010) and soil enrichment (Lunt, 2011). Latrines may provide a rich microhabitat for seedlings, thus the African civets act as seed dispersal agent (Randall, 1977; Pendje, 1994).

Civets do not bury their feces, but they accumulate it in open places. During defecation, perineal glandular secretion is added to the feces, making it to have a long-lasting odor. African civets use each civetry for a long period (Wondmagegne Daniel, 2006; Ayalew Berhanu, 2007; Bekele Tsegaye *et al*., 2008b). They establish their latrines near pathways in open and relatively dry soil. Civets have a habit of following regular paths (Ayalew Berhanu *et al*., 2013). Latrine sites are also a good source of communication for civets, having high density of scent marked objects surrounding civetries (Wondimagegne Daniel, 2006; Ayalew Berhanu, 2007; Bekele Tsegaye *et al*., 2008a).

Translocation of the dung piles did not affect the defecation behavior of the African civets (Bearder and Randall, 1978). Most latrines are located in clearnings and scats are piled on top of each other (Bearder and Randall, 1978; Bekele Tsegaye *et al*., 2008a). Individuals visit more than one latrine sites and a specific latrine will be used by more than one African civet (Randall, 1977).

African civets are sexually mature at the age of 9–12 months (Ewer and Wemmer, 1974). They have a gestation period of 60 to 81 days (Kingdon, 1977). Captive females give birth to the first litter at about 14 months of age (Ewer and Wemmer, 1974). Females are polyestrous and are able to have two or three litters per year. If a mother loses her kitten, she will undergo estrous again in 14 days. Litter size in captivity ranges from 1 to 4 young (Ewer and Wemmer, 1974). The average lifespan of the African civet is 15 − 20 years. They have a life span of 15 years in the wild (Jones, 1982) and 28 years in captivity (Grzimek, 1990; Weigl, 2005).

Breeding season of civets varies from region to region. In southern Africa, the favorable breeding season is the warm, wet summer months from August to January, when insects are plentiful (Skinner and Smithers, 1990). In Ethiopia, Kenya and Tanzania, the breeding season of the civet is from March to October (EWCO, 2002). But, there is no strict seasonality in the reproduction of African civet in West Africa (Rosevear, 1974). In New Jersey Zoo, more than 86% births occurred between May and October (Mallinson, 1973).

Young are born fully furred, weigh about 300g, with eyes open and in an advanced state relative to most carnivores (Ewer and Wemmer, 1974). The coat color during birth have poorly defined pattern, becoming clear during the early stages of development (Skinner and Chimimba, 2005). Young are able to crawl at birth and the hind legs support the body by the 5^{th} day (Ewer and Wemmer, 1974; Kingdon, 1977). The adult pelage pattern is already clear in the early stages of development (Skinner and Smithers, 1990). They begin to actively explore outside the nest within 17−18 days after the birth. Play behavior starts at around 14 days after birth and they start to eat solid food before weaning. They depend completely on the milk of the mother for at least six weeks. Weaning occurs from 14 to 16 weeks (Ewer and Wemmer, 1974). The mother carries the young in her mouth, grasping them by the middle of the back or by the neck (Ewer, 1973).

No evidence is available about the captive breeding of the African civet in Ethiopia. But trial by a farmer in his farm ended without success (Pugh, 1998). During his first trial, the male and the female civets were accommodated in a small cage and two kittens were born. The male killed and ate both offspring within 24 hours of birth. In the second trial, two kittens were born, but the mother killed and ate both offspring within 15 days. In the third attempt, two kittens were born, but the mother killed and consumed both of them within 24 hours (Pugh, 1998). Zoo mothers have been reported to kill and eat their young at birth (Mallinson, 1973). This behavior may be associated with shortage of food in the captivity. The trial indicated that the size of kittens per litter was two in captivity in Ethiopia.

African civets are solitary during most of their life (Kingdon, 1997). They are seen in groups of two or more, only during reproductive activities for a brief period of time. They use olfactory signal as a major means of communication between conspecfics (Ray, 1995; Bekele Tsegaye *et al*., 2008a). The scent mark of civets can stay for a long period in their habitat.

Communication between conspecifics is important not only in social organisms, but also in solitary species, to ensure reproductive success (Clapperton, 1989). Intraspecific communication between solitary carnivores and between social carnivores is achieved primarily by olfactory signals (Macdonald, 1980). Civets are generally solitary, but they have a variety of visual, olfactory and auditory means of communication. Scent glands play a major role in the social life by leaving scents with specific communication signals such as social, reproductive and individual dominance strategy (Eisenberg and Kleiman, 1972). They are relatively short sighted, but hearing is acute, and olfaction is the key sense of communication (Kingdon, 1997). They also produce sound for communication, especially to show aggression such as growl, cough-spit and scream (Rosevear, 1974).

Scent communication has advantages when compared to other types of signals, especially in places where visual and auditory signs are difficult to detect (Gorman and Trowbridge, 1989). Odors can be released into the environment through scents that allow a spatial and temporal record of the behavior and movements of an individual (Gorman and Trowbridge, 1989). Scent marking can remain effective for long periods of time, even when the animal is no longer present at the marked site. This feature enhances its importance for animals, such as carnivores, that usually live in medium to low densities and defend large territories. Carnivores have scent glands located in different body parts corresponding to different types of scent marking. For instance, flank glands in European badger (*Meles meles*), hind-leg glands on the feet of the golden jackal (*Canis aureus*) and perineal glands near the anus of the common genet and African civet (Gorman and Trowbridge, 1989; Ray, 1995). Mostly, common sources of odorous glands of mammals are identified from uro-anal region given that urine and feces are the main scent-marking agents of carnivore predators (Macdonald, 1980). This behavior is common in the majority of the members of the carnivore families (Macdonald, 1980). For some species, the use of latrines as long-term defecation sites is well known as in the African civet (Ray, 1995) and European badger (Do Linh San *et al*., 2007).

Scent marking is one of the major forms of communications in civets. Civets scent mark sign-posts in territories using the perineal glandular secretion and feces. They mark environmental sign-posts such as tree trunks, stumps, stones, thickets, dry logs, poles and fence or grass along road sides using perineal glandular secretions. The height at which they scent mark mostly ranges from 35 to 40 cm above the ground (Bekele Tsegaye *et al*., 2008a). They mark sign-posts in their natural habitats, but they mark more frequently on objects near their civetry sites. The amount of perineal glandular secretion at the marked site varies with season and habitat type. Wondmagegne Daniel (2006) and Bekele Tsegaye *et al*. (2008a) reported an increase in the amount of glandular secretion during dry season. Some of the sign-posts were marked immediately after removal of the glandular secretion from scent marked sites and while others remained without remarking probably due to the information conveyed on each sign-post.

Scent marking is not exclusively associated with territorial purpose in all mammals. In some species, it might be for spacing out (Goddard, 1967). The extensive marking behavior shown by female mammals before and during estrus is more related to breeding (Eisenberg and Kleiman, 1972). Scent marking permits the chemical exchange of information among animals with overlapping home ranges, but tends to move and forage alone (Eisenberg and Kleiman, 1972). Scent marking gives information with respect to age, sex and reproductive conditions. Generally, scent marking is used in orientation of the movement of individual, integrating social and reproductive activities and also serving in more than 25 different functions in a variety of mammals (Mykytowycz, 1970; Balakrishnan and Alexander, 1985).

1.2.3. Threats to civets

African civet is considered as a common animal in most of the habitats known for its existence (Ray *et al*., 2008). Available data on population dynamics of the African civet is fragmented and represent only few localities in some countries. Population density of 9, 3 and 7 individuals per km^2 was estimated from Menagesha-Suba State Forest, Jimma and Wondo Genet areas, respectively, based on fecal counts from civetries (Bekele Tsegaye, 2006; Wondmagegne Daniel, 2006; Ayalew Berhanu, 2007). Population density of 1 individual per km^2 reported from south west Gabon based on track count along transects in lowland forest (Prins and Reitsma, 1989). However, the population trend of the African civet in any of its known habitat is unknown in the absence of continuous studies (Ray *et al*., 2008).

It is listed as "Least Concern" in the IUCN Red list as the species has a wide distribution range, its presence in a variety of habitats, its relative commonness across its range and presence in numerous protected areas and in human mediated areas (Ray *et al*., 2008). However, localized declines were reported from Congo (Colyn *et al*., 2004), South Africa (Rowe-Rowe, 1992) and western Ethiopia (Yilma Delellegn, 2000). Main reasons for the decline in the population of this species in these areas are different. In Congo, the cause is hunting for meat (Colyn *et al*., 2004; Ray *et al*., 2005). The local reduction in population size reported from former northern Transvaal Province, South Africa is due to habitat transformation (Rowe-Rowe, 1992). In western Ethiopia, the reduction in the number of civet is due to intensive trapping by civet farmers to replace the dead individuals in captivity and to increase the number of civets in their farms (Yilma Delellegn, 2000). Nearly 40% of the civets captured from the wild die within the first three weeks of capture (WSPA, 1999). Civet farmers replace died ones from the wild, which may cause threat to local civet population. Hunting might be rendered more vulnerable in areas where preferred bush meat is scarce. African civets are one of the most abundant mammals found in bush meat markets in south east Nigeria, being used for both food and skin (Angelici *et al.*, 1999). They are also hunted for meat in Cameroon, Congo, northern region of Central African Republic and Sierra Leone. However, it is among the bottom ranked species in both vulnerability and threat categories. Higher reproductive potential, small home range and small body size help African civets not to be vulnerable to changes in the ecosystem unlike big carnivores (Ray *et al*., 2005). An increase in the human population might not affect generalist species that are probably less sensitive to habitat changes (Do Linh San *et al*., 2013). They have relatively wide habitat tolerance within the more mesic areas where they get cover for their daytime rufuges. They are tolerant of agriculture and other human modified habitats. They are adapted well to degraded secondary forest (Grubb *et al*., 1998). Thus, they persist in much of their ranges without targeted conservation activities.

African civets are killed for raiding domestic animals and crops. Farmers view the civets as a pest, due to their raiding of gardens and poultry. Farmers easily hunt civets by dogs, snares or shoot by spotlight. Indiscriminate methods kill six civets for each jackal in South Africa (Rowe-Rowe, 1992). Populations in close proximity to human settlements are vulnerable to predation by domestic dogs (Kingdon, 1977). Road kill is also a threat to African civets. They are slow-moving and often killed on roads (Fig. 3).

Figure 3. A road kill of African civet on the Shashemene to Hawassa road (a – Picture of African civet killed by car accident, b – asphalt road from Shashemene to Hawassa

1.2.4. Economic importance of African civets

People in different societies use civets and their products for various purposes. The perineal gland secretion of civets is used in perfume industry, traditional medicine and to flavor tobacco (Xavier, 1994; Kingdon, 1997). Civet musk increases the durability of perfumes and keeps the flavor natural. In Ethiopia, people use civet musk in traditional medicinal practice for headache, discoloration of skin, etching and even against cancer (Jemal Mohammed, 1999).

In many parts of Ethiopia, civet farming is practiced as a means of income (EWCO, 1999). The country officially exports on an average 1,000 kg of civet musk every year. The majority of it (97%) is exported to France (Jemal Mohammed, 1999) to support perfume industry. For instance, between 1985 and 1996, 13,679 kg of civet was exported from Ethiopia. Practically, this would have used to produce 118,367 million of 30 ml bottles of perfume, generating an income of USD 6.391 billion (WSPA, 1998). However, Ethiopia (the producer and exporter) received only 6,155,100 USD, which is equivalent to the profit of the perfume industry from just one kilogram of the musk.

The use of civet coffee ("Kopi Luwak") has been reported from Indonesia and Philippines (Marcone, 2004). In Indonesia and Philippines, civet coffee is produced from Asian palm civet (*Paradoxurus hermaphroditus*) from *Coffea robusta*. When the civets eat the fruits, they digest the flesh and pass the beans through their digestive tract. During the passage through the intestine, micro-structural properties of the coffee beans are altered by the enzymatic actions. Those beans are harder, more brittle and darker in color than normal coffee beans. Digestive enzymes penetrate through the coffee berry and reach the actual bean surface (Marcone, 2004). The internal fermentation by digestive enzymes adds a unique flavor to such beans. These beans are lower in total protein (Marcone, 2004). This lower level of protein decreases the bitterness of "Kopi Luwak", which is highly valued.

People in Cameroon, Central African Republic, Congo, Nigeria, Sierra Leone and Zanzibar eat civet meat (Ray *et al*., 2005). The meat of the African civet is expensive in northern Congo, such that hunters opt to consume it themselves (Ray *et al*., 2005). In Cameroon, 1% of the total biomass of the hunted animals was of African civet. Among the carnivores trapped by hunters, African civet represents 18% of the overall biomass (Nzouango and Willcox, 2000). In Kisangagi region of Congo, African civet was represented in 2.3% of the small carnivores captured by hunters (Colyn *et al*., 1987). Hodgkinson (2009) reported from Central African Republic that the African civet was the only carnivore sold in markets in the Bayanga region, where people consume more than 408 kg of civet meat per year (Hodgkinson, 2009). However, due to cultural and spiritual belief, there is no habit of eating civet meat in Ethiopia. Trophy hunting is rare for civet. But in Cameroon, civet is legally hunted. Fifty nine civets were hunted legally during a 20 year period in Cameroon (1987−2007) (Croes *et al*., 2008).

Civets raid farms (particularly papaya and maize) and poultry houses. They are occasionally blamed for killing lambs (Kingdon, 1977). The level of damage caused by civets and perception as a pest varies from area to area. For example, people around Bénoué National Park in Cameroon consider civet as the main predator causing 18% of livestock income lost annually (Weladji and Tchamba, 2003). Investigations in the same area revealed 24% of the respondents experienced loss of livestock to civets, the highest for any predators (Weladji and Tchamba, 2003). African civet in this area most frequently target poultry. But Croes *et al*. (2006) have found that the level of predation by African civet was negligible compared to that of wild cats. The same study has revealed that the African civet was responsible for taking only 13 chickens, where as wild cats killed 1717 chickens.

1.2.5. Civiculture in Ethiopia

Human use of civet musk has been there since ancient times (Pankhurst, 1961). One of the items among the gifts to King Solomon from the Queen of Sheba (1013−982 BC) on her visit to Jerusalem was civet musk (Pankhurst, 1961). For thousands of years, people have been collecting the musk to support perfume industry. In the early history, civet musk was expensive in Ethiopia. Its value was outcompeting ivory, myrrh and gold (Jemal Mohammed, 1999). It was even used as a currency (Pankhurst, 1961). French physician, Charles Poncet, noted that Enfranz was an important town for civet farming during his arrival in Gondar in the 17th Century. Civets were kept in captivity and their perineal gland secretion was collected weekly. Poncet had witnessed civet musk being traded alongside ivory, tamarind and gold (Yilma Delellegn, 2003). Civet musk trade was referred in the 18th century expedition by Napoleon Bonaparte to Egypt (Pugh, 1998). In 1872, Anatolia Cheche witnessed civet farming in Aba Jiffar Abagambo's palace, who was the King of Jimma in Ethiopia (EWCO, 1999).

To begin with civiculture in Ethiopia was initiated by the Royal family. In early Ethiopian civet musk trade history, it was directly exported from Gondar (the capital of Ethiopia) (Pankhurst, 1961). Civet musk was a major export item of Ethiopia in the beginning of 18th century. Woodford (1990) revealed that civet musk accounted for 13% of the export items of Ethiopia in the 1840s. Later, civet farming was introduced in the south and southwestern Ethiopia (Mesfin Admasu, 1995). Limu district in the Keffa region was the first area to practice civet farming in the southwestern Ethiopia. Since then, civet farming practice spread to the neighboring areas including Enarya, Jimma and Wellega (Pankhurst, 1961). However, at present there is no civet farm in Gondar and in the northern parts of the country and it is shifted to the south and southwestern parts of the country.

Ethiopia produces 90% of the world's civet musk. In Ethiopia, Wellega and Illubabor are the areas with high number of legalized civet owners, followed by Kaffa, Dilla and Showa regions. In these five areas, a total of 3,790 captive civets are registered with 229 farmers (Tesfaye Hundessa, 1996). The amount of musk produced is proportional to the body mass of the civet. An adult male can produce as much as 6.4 g of musk every 5 days. Smaller males produce only about 3.5 g (Hillman, 1992). Even though maintaining civets in captivity for musk is an important source of livelihood of local people, animal abuse has been recorded in this practice (Pugh, 1998). The methods of capturing, handling and musk collection procedures are not practiced in an ethical way (WASP, 1999).

Civets are trapped from the wild using a noose with a bell attached. The trap usually catches the leg of the civet (personal observation). Trappers charge between 400 and 1000 Ethiopian Birr for a civet, payable after two months of capture to ensure survival. Majority of the captured civets die within the first three weeks of captivity after severe mental distress and physical pains caused during capture, transportation and quarantine (Pugh, 1998). Dead civets are replaced by new ones trapped from the wild.

Both licensed and non-licensed farmers keep civets in very small cages. Most civet farmers have 10−15 civets in individual hut. The cages are placed in rows on trestles in dark rooms of smoke-filled huts. In the hut, fire is left smoldering to maintain temperature, which farmers believe would increase the quantity of musk. No bedding is provided in the cage, and hypothermia is a common cause of death (Pugh, 1998). Hygiene is usually very poor in such huts and urine and feces are left to decay on the floor itself (Scherf, 2000). Traditionally, civet farming of the family has been handed over from the father to one of the sons for generations (Yilma Delellegn, 2003).

Farmers extract musk every week using a spatula shaped tool made of cow horn (Kingdon, 1997; EWCO, 1999). They get an average of 5g musk per animal per week (Hilman, 1992). Three persons are involved in the musk extraction process. For musk extraction, each cage with the civet is taken out and sticks of the cages are removed from one end. A rod or a stick pocked through a gap to harness the civet at the neck and then a sack is held over the (exit) entrance securing the civet from escape and to grab the hind legs of the animal (Pugh, 1998). After exposing the perineal gland, the gland is squeezed gently until the musk exudes. During this process, the animal is severely distressed and injuries may also occur.

Civet farming is less expensive with simple infrastructure and it is profitable. Inputs in civet farming and musk production consist of housing, appropriate food items for the civets, which consist of maize, fruits, eggs and meat (Tadesse Habtamu, 2014). Equipment required for civet farming and civet musk collection, packing and shipping to the market place are not complex. They can be procured locally from companies engaged in metal and wood industries. As the farming process does not require large number of employees, there is no need of offices and furniture.

Main activities in civet farming include feeding, cage cleaning, disease treatment and musk collection. For treatment of sick individuals, a veterinary nurse is enough. The only experience required for civet farming is knowledge of handling animals. Most Ethiopian farmers have knowledge in handling domestic animals. So, they can easily manage civet farms with little additional training on civet maintenance and musk extraction. The same civet can serve for musk and coffee bean production. During coffee fruiting season, the cost for feeding the animal can be reduced as the animal can be supplemented with coffee berry, which they defecate as civet coffee (Marcone, 2004).

Ethiopian farmers have traditions, myth and cultures surrounding civiculture. Civet farming has been a family business and has been subjected to numerous traditional beliefs and superstitions. There is belief of limiting the number of people to have direct contacts with the animals for fear of reduction in the amount of civet musk produced. This belief has made it difficult for government officials and other authorized people to control and monitor civet farming. Obtaining data on health and overall conditions of the animals in captivity is hardly possible as a result of non-cooperation of civet owners in the context of their beliefs.

In the existing civet farming system in Ethiopia, old and dead animals are replaced with new individuals trapped from the wild (Yilma Delellegn, 2000). This may affect the wild populations of civets in farming areas. The possibility of breeding civet in captivity is recorded in New Jersey Zoo (Mallinson, 1973). If this is practiced in Ethiopian civiculture, the pressure on natural populations can be reduced.

There are a number of stakeholders in civet farming and musk industry such as subsistence farmers, middlemen, exporters, national and regional government authority, animal rights groups, quality control laboratories, perfume manufacturers and consumers. The coordination among the stakeholders is very loose in civet farming and musk producing activities.

Despite their potential importance in the Old World ecosystems as predators, frugivores and ecosystem regulators, very little is known about the African civet biology, ecology, behavior and socioeconomic importance, largely due to their secretive nature and nocturnal behavior. Understanding the ecology of African civets give information on the ability of this animal to co-exist and co-adapt to human mediated habitats. The information is valuable for structuring effective management plans for conservation of the species. Therefore, the present project was proposed to investigate the ecology of African civets in Hawassa and Wondo Genet areas, Ethiopia.

1.3. Objectives

1.3.1. General objective

The main aim of this research was to investigate the ecology of the African civets in Hawassa and Wondo Genet areas, Ethiopia.

1.3.2. Specific objectives

The specific objectives of this research were:

- to estimate population density of the African civet in different habitats during different seasons,
- to investigate diet composition of the African civets in different habitat types,
- to investigate the seeds that dispersed by civets,
- to analyze physical and chemical parameters of soils taken from civetry and non-civetry locations in the study areas and
- to analyze scent marking pattern of civets

Based on the above objects, the following questions are raised for clarifications.

- Is density of civetry related to the civet populations in the area?
- Which habitat is with the highest civetry density and populations of civets in the study area?
- Do diet variety and composition differ seasonally and spatially in the present study area?
- In what way civetries help to improve the nutrient quality of soils in civetry sites?
- Is scent marking by civets distributed uniformly in their home range?

2. STUDY AREAS AND METHODS

2.1. Study Areas

The current study was carried out in Hawassa watershed, mainly in Hawassa and Wondo Genet areas. Hawassa area represents the lower catchment of the watershed, while Wondo Genet belongs to the upper catchment. The study area is located in the Rift Valley system in the southeastern escarpment of the Great Ethiopian Rift Valley system (6° 58’−7° 30’ N and 38° 22’–38° 42′E). Hawassa and Wondo Genet areas are located south of Addis Ababa at a distance of 263 and 273 km, respectively. These areas are part of the south-central highland of Ethiopia (Fig. 4). A total of 1450 ha of sample area was used during the present investigation.

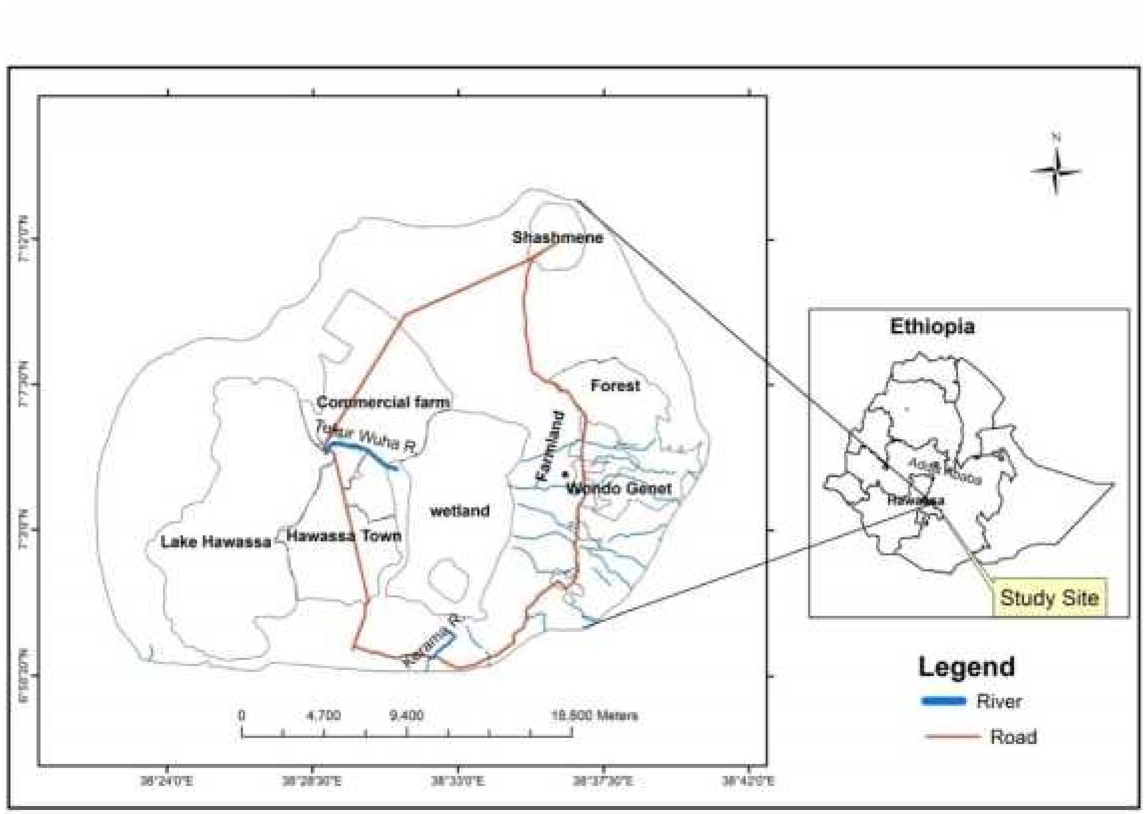

Figure 4. Map showing the locations of the current study areas in Ethiopia

The sample areas comprised of a total of 1600 ha of commercial farm, farmland, natural forest and urban areas. The altitude of the study area ranges from 1,680 to 2,320 m asl. The watershed ecosystem is representative of *Accacia-Commiphora* woodland with pockets of natural forests on the Wondo Genet escarpments, swamp vegetation near the lake and *Hypernia* grassland with scattered *Acacia* (IBC, 2005). The remnant forest in the study area is characterized as upland forest (Friis, 1986), or submontane seasonal rain forest (Chapman and White, 1970), termed as Afromontane rain forest (Friis, 1992).

Hawassa area is located at the eastern escarpment of the Great Ethiopian Rift Valley within coordinates of 6º 58’−7º 30’ N and 38º 22’−38º 29' E. This area includes Hawassa Town, the surrounding commercial farm and the lake shore. The lake is located on the western side of the town (Fig. 4). The altitude of this site ranges from 1680 m asl at the lake shore around Piassa to 1740 m asl towards the northern part. The lake has a surface area of 90 km^2 (Makin *et al.*, 1975) and a catchments area of 1250 km^2.

In Hawassa area, two sample sites were selected for the current study. In the commercial farm site, most of the extent of the land is covered with maize (*Zea mays*). After the harvest, the area is left as a bare land during the rest of the year. Only few scattered *Acacia* trees are observed in this area. Towards the northeastern part of this area, Cheleleka wetland and towards the northern part is peasants’ farm. In the commercial farm, a sample area of 250 ha was selected for this research. The other sample site in the lower catchment was urban area, located at the shore of the lake, bordering the town. Main features of this sample site are the lake shore vegetation, fragmented indigenous forest and recreation areas. Also, there are small farms along the lakeside that belongs to farmers for cultivating sugarcane, cabbage, tomato, taro (a tuber crop), banana and maize. This area is in a transitional state from forest to urban area. An area of 100 ha was investigated during the current study in this site.

Meteorological data for the study area was collected for the years 1995−2013 from the National Meteorological Agency, Hawassa Region. Hawassa area has a dry, sub-humid climate with a mean annual rainfall of 977 mm during the rainy season (March to October). The period from December to February is dry. The highest bimodal mean monthly rainfall recorded was 107 mm during April and 127 mm during September (Fig. 5).

Annual mean temperature of the area was 20^{o}C and annual mean maximum and minimum temperatures were 27^{o}C and 13^{o}C, respectively. The highest monthly mean temperature recorded was 30^{o}C during February and the lowest mean temperature recorded was 10^{o}C in November (Fig. 5).

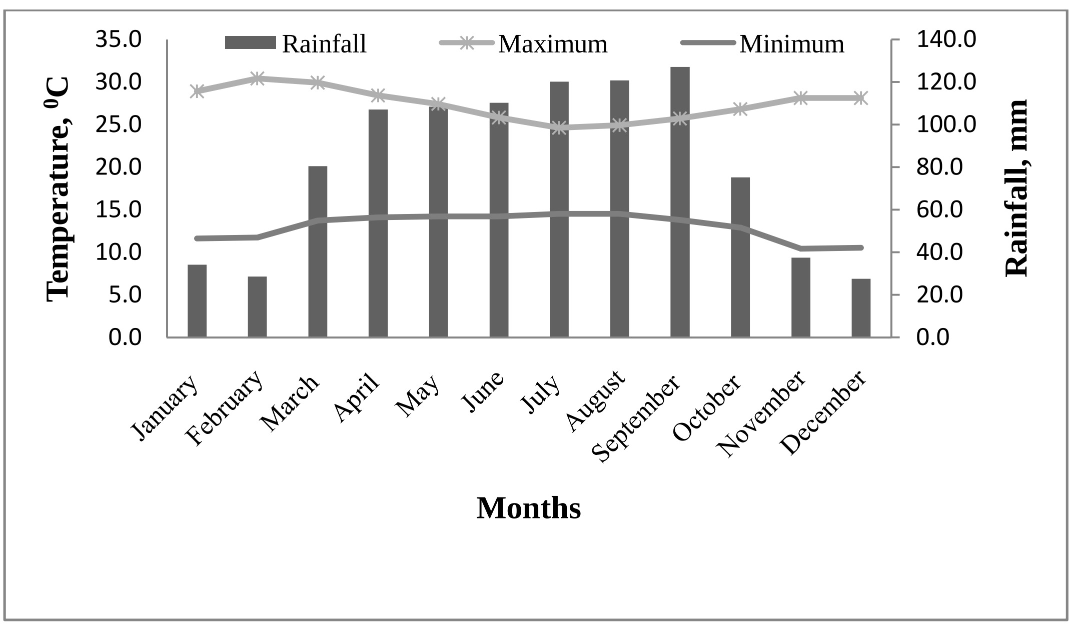

Figure 5. Rainfall and temperature patterns of the lower catchment area (Source: National Metrological Station of Ethiopia, Hawassa Region, 2013)

In this area, there were different types of land-use: metropolis, government and private owned farms, settlements, grassland, water body and open areas. There are fragmented indigenous remnant forests near Tikur Wuha and Amora Gedel, serving as refugia for larger mammals and birds in the area. *Ficus vasta*, *Cordia africana*, *Croton macrostachys* and *Eucalyptus* spp. are some of the dominant trees in the remnant forests. The lake shore is composed of aquatic vegetation, shrubs, large trees and scattered housing units. Part of the shore is covered with some cultivated plants including maize, taro, sugarcane, banana, cabbage and tomato. This area is a place for entertainment for local people and visitors.

This area has both aquatic and terrestrial life forms. African civet, colobus monkey (*Colobus guereza*), vervet monkey (*Chlorocebus pygerythrus*), olive baboon (*Papio anubis*), common dwarf mongoose (*Helogale parvula*), white-tailed mongoose *(Ichneumia albicauda*), serval (*Leptailurus serval*), spotted hyena (*Crocuta crocuta*) and striped hyena (*Hyaena hyaena*) are among the terrestrial mammals found in the area. Hippopotamus (*Hippopotamus amphibius*) is the semi-aquatic mammal in the area. Aquatic life forms mainly include six species of fish, *Oreochromis niloticus, Labeobarbus intermidius, L. amphigrama, Aplochelichthys* sp., *Clarias gariepinus* and *Garra* sp. (Demeke Admassu, 1996). The dominant zooplankton species are *Mesocyclops aequatorialis, Thermocyclops consimilis, Diaphanosoma excisum, Brachionus* and *Keratella* (Seyoum Mengistou and Fernando, 1991). The littoral habitat is covered by an extensive belt of submergent and emergent rooted vegetation, which extends about 150 m offshore (Tudorancea *et al*., 1988). The macrophyte vegetation includes *Cyperus* sp., *Nymphea caerulea*, *Potomogeton* sp., *Typha angustifolia*, *Paspalidium geminatium* and *T. latifolia*. The shore and the surrounding wetland areas are occupied by both aquatic and terrestrial birds. A total of 138 species of birds was recorded from this area (Ayalew Berhanu, 2010).

The town and the lake form a popular recreation site for local and foreign visitors (BirdLife International, 2009). The lake and the surrounding areas play a vital role in the economy of the society due to the availability of market for the products, good means of transportation, suitability of the area for irrigation and the presence of fertile soil around the lake (Gessesse Dessie, 2007). Fishing in the lake is not managed and open to anyone with or without the knowledge of fishing. It is serving as a good opportunity to unemployed local people. Among the three commercially exploited species in the lake (Tilapia, Catfish and Yellowfish), Tilapia yield accounts for about 85% by weight of the total annual landings. As a result, the Tilapia stock has already shown signs of over-fishing (LFDP, 1998; IBC, 2005).

Wondo Genet is part of the upper catchment area of Lake Hawassa watershed. It is located at 7^o 06'−7^o 07' N latitude and 38^o 37'−38^o 42' E longitude (Fig. 4). The remnant forest covers about 10 km^2 of land, occurring in the eastern boundary of the southern Rift Valley (Mersha Gebrehiwot, 2003). Wondo Genet means "place of paradise" and named by the late Ethiopian Emperor Haile-Sillassie I. In upper catchment area, two sample sites were selected for the current study. One of these, the natural forest sample area is located at the sloppy area on the remnant forest. This sample area covers 500 hectare of land. Farmland was another habitat selected for this investigation. Farmland area together with associated settlements has an area of 600 hectare. The altitude of these study sites ranged from 1,740 to 2,320 m asl, and the slope varies between 2−30% (Gessesse Dessie and Kinuland, 2008).

Topographically this area is characterized by rolling upland, where the higher altitudes and steep slopes support natural forests and lower altitudes and gentle terrain consists mainly of farmlands. In farmlands a significant number of diverse natural on-farm trees grow (Fig. 6). Common on-farm trees include *Cordia africana*, *Podocarpus falcatus*, *Ficus* spp., palm trees and *Croton macrostachyus*. The soil is characterized by a well-drained loamy or sandy loam (Eriksson and Stem, 1987) and well supplied with all available plant nutrients except phosphate (Makin *et al*., 1975). Soils at lower altitude are dark brown in deep alluvial sediments whereas soils at the slopes of the study area are shallow, mostly less than forty centimeter depth (Zewdu Eshetu and Högberg, 2000).

Figure 6. Trees of *Ficus* sp. (the bigger stem) and *Dracaena steudneri* (broad leaf plant near to *Ficus* sp.) in near human settlement

There are seven major streams sourced from the upper catchment and enter the Chelelleka wetland before joining Tikur Wuha river. This is the only river, which drains to Lake Hawassa from the north. In Amharic language, Tikur Wuha means black water. It is called so because of the brownish to black color of the water due to high concentration of fluoride. Belle, Wosha, Worka, Bobagnamo, Kella, Basha and Meribo are the seven streams, that originate from upper catchment and part of the drainage system. All these streams, except Bobagnamo, drain throughout the year, even though the volume of water is reduced during the dry season due to diversion for irrigation at various locations. Wondo Genet is circled by a chain of mountains in its boundary from Toga to Tulla and forms the closed basin of Lake Hawassa.

Precipitation and temperature data of the upper catchment area were collected from Wondo Genet Meteorological Station located in the College of Forestry and Natural Resource Management Campus. Precipitation pattern in this area is bimodal with a sub-humid tropical climate. The two rainy seasons are the short rainy season from March to April and the long rainy season from July to September. The mean annual rainfall is 1171.5 mm. Peak rains occur during April and September (Fig. 7.

The period from December to February is relatively dry. The mean annual temperature of the area is about 20°C with maximum day and night temperature in February and March. The mean maximum monthly temperature recorded was 29.8^{o}C during February. The minimum mean monthly temperature was 10.8^{o}C recorded in January. The coldest period was during December and January (Fig. 7).

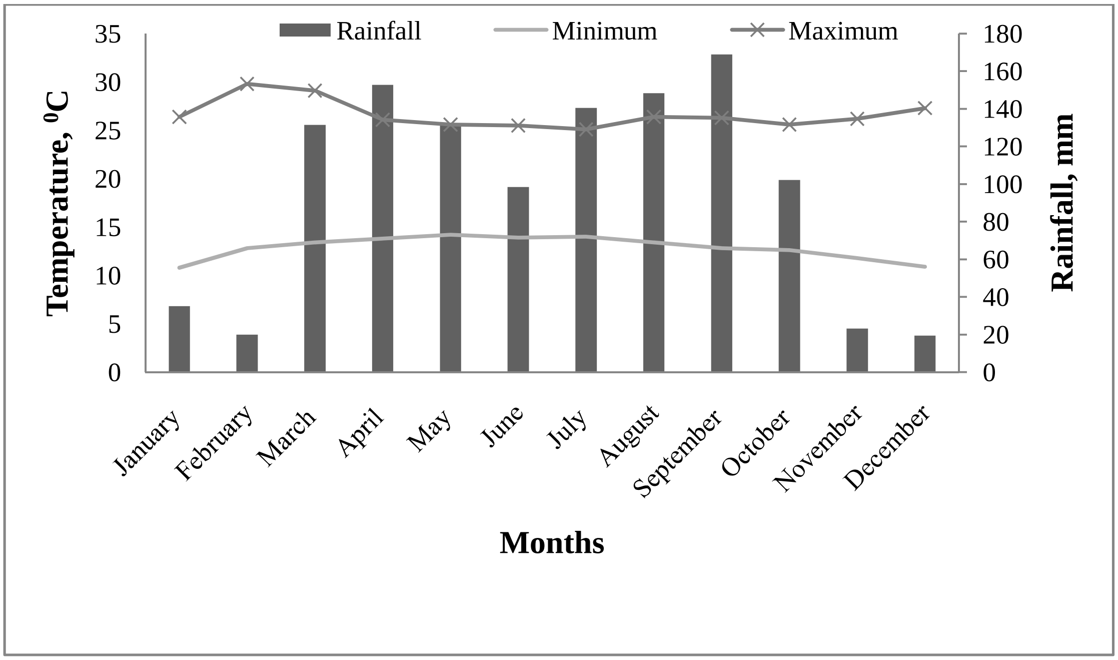

Figure 7. Rainfall and temperature patterns of the study sites in the upper catchment area (Source: National Metrological Station of Ethiopia, Wondo Genet, 2013)

The remnant forest vegetation in upper catchment area is categorized as dry afro-montane forest, at present confined only to the mountain slopes due to human pressure (Tesfay Teklay, 2005). The natural forest consists of high mixed dense canopy forest. There are 53 species of naturally regenerated trees and shrubs belonging to 31 Families in the area (Eshetu Yirdaw, 2002). *Cordia africana*, *Albizia gummifera*, *Croton macrostachys*, *Ficus* spp., *Podocarpus gracilor*, *Aningeria adolfi-frederici*, *Celtis africana* and *Milletia ferruginea* are the dominant tree species in the natural forest. Most of the exotic species in the plantation forest is *Eucalyptus* spp., followed by *Cuperssus*, *Pinus* sp. and *Grevillea robusta*. Although the role of biodiversity maintenance by plantation forest is negligible, it provides resources for construction and fire wood requirements of the local people. There are also woodlands with tree species like scattered *Acacia* spp. and grasses.

In this area, there are various species of mammals, birds, fish, reptiles, insects and amphibians. Olive baboon, vervet monkey, colobus monkey, African civet, common dwarf mongoose, white-tailed mongoose, Abyssinian genet (*Genetta abyssinica*), spotted hyena, striped hyena, rock hyrax *(Procavia capensis*), rabbit, gazelle (*Gazella* spp.), bush pig (*Potamochoerus larvatus*), hippopotamus, common warthog (*Phacochoerus africanus*), aardvark (*Orycteropus afer*), serval, leopard (*Panthera pardus*), side-striped jackal (*Canis adustus*), Menelik's bushbuck (*Tragelaphus scriptus*), squirrel and porcupines (*Atherurus* spp.) are some of the mammals observed in the area. Among these, civets, hyena, mongoose, baboon and vervet monkey are the abundant ones. Mountain nyala (*Tragelaphus buxtoni*) was present in the area, but since the mid-1980s they are not reported from the study area (Gessesse Dessie and Kleman, 2007).

There are 159 species of birds in the upper catchment area, out of which two are endemic to Ethiopia (Yellow-fronted parrot (*Poicephalus flavifrons*) and Sidamo lark (*Heteromirafra sidamoensis*)) (Mesay Digafe, 2008). Monitor lizards and snakes are among the common reptiles in the area. Due to high diversification of plant and animal species in Wondo Genet, a wildlife reserve was proposed to establish in the Abaro and Wondo Genet area three decades ago (Makin *et al* ., 1975). However, it is yet established.

Wondo Genet area has one of the most productive agricultural lands in Ethiopia. Most of the areas have access for irrigation from the upper catchment area. Due to suitable resources and accessibility of market, and the presence of good network of roads, farming practices in the area are cash crop oriented (Gessesse Dessie, 2007). The area has crops such as *Saccharum* spp., *Coffea arabica*, *Catha edulis, Mangifera indica*, *Persea americana*, *Prunus persica*, *Carcia* *papaya*, *Psidium guajuova*, *Impoma batatas*, *Solanum tuberosum* and *Casmiroa edulis*. Exotic species such as *Grevillea robusta*, *Pinus patula*, *Eucalyptus* spp. and *Cupressus lusitanica* occupy plantation forests. The area is known for enset (*Ensete ventricosum*), the drought resistant food plant. It is distributed in most of the areas in the region.

The majority of the farmers in the area are engaged in subsistence farming of crop cultivation and livestock rearing. Only 22% of the farmers are engaged in crop production. Farming system is both rain-fed and seasonal irrigation. The size of individual holdings ranges between 0.1−2 hectares. Maize, enset, potatoes and sugar cane are the important crops of the area. Almost all the enset and maize produced here are used for household consumption. Most of the farmlands (65%) are under cash crops and the rest used for food crop production (Teshale Woldeamanuel, 2003). Currently, sugarcane surpasses other crops including potato, where irrigation is possible. Its expansion is related with the current high price for the product in the market, use of its byproduct as livestock food and high yield. In areas inaccessible for irrigation, farmers depend on maize, khat and sweet potato production with rain-fed agriculture.

2.2. Methods

Civetry sites were searched in all the study sites. All possible areas within the study sites were investigated extensively. Civetry search focused mainly on wildlife tracks. Civet trappers, forest guards, farmers, cattle herders and firewood collectors were asked whether they have seen civetries anywhere in the study area. The researcher and a well trained assistant moved along the pathways in opposite direction searching for any sign of civet defecation sites. As there were a number of sign-posts surrounding civetries (Ayalew Berhanu, 2007; Bekele Tsegaye *et al*., 2008a; Wondmagegne Daniel *et al*., 2011), scent-marked objects were tracked to identify the location of the civetry.

Once a civetry was located, distance from wildlife tracks, surrounding vegetation, seeds germinated on and/or the surrounding areas and number of marked objects within 50 meter radius were recorded. Also using a Geographical Positioning System (GPS) (Garmin 12 eTrex®, Garmin Ltd.), each civetry coordinates was marked. Age of the civetry was estimated using the area coverage (amount of dung pile deposited), seeds germinated in it, information from civet trappers and the local community and/or farm owners when civetries were located in farmland (e.g. civetry with an age of 15 years was identified based on the information from the farm owner). Civetries were classified as open, semi-open and closed based on the vegetation cover surrounding the civetry. It was considered ‘open’ when no trees with dbh > 10 cm surrounding the civetry within 4 meter radius, ‘semi-open’ when covered with vegetation with dbh of 10 cm or more within 2 to 4 meter radius and ‘closed’ when the civetry was located under canopy or closed vegetation.

Defecation pattern was recorded based on the distribution of droppings on the civetry. Number of dung present per latrine site and deposition pattern either scattered or clumped together were observed. To see the specific pattern of defecation at a given civetry, observation was made based on the size of the feces and the location of each dropping in the area. It was recorded as defecated towards the center or away from the center of civetry.

Once a civetry was identified, individual feces were counted on a daily basis during both wet and dry seasons. During the process, only fresh droppings were counted. Data were collected for two dry seasons in 2011 and 2012 from November to March and wet season data were collected in 2012 and 2013 from June to September, each year. The density of civets was estimated from fecal density. Population density was estimated using all civetries identified within the sample sites. During this investigation period, 16 civetries in the natural forest, 21 in the farmland, two in urban habitats and four in commercial farm were used for estimating civet population density. Care was taken to avoid double counting. Loose feces were counted carefully without mixing with other feces. Fecal counting was performed for 13 days in each month of the study season. Twigs or leaves were put over the surface of the old feces to distinguish the fresh feces.

During the current study, commercial farm, farmland, natural forest and urban areas were the four habitats selected for diet analysis. Only 11 representative sample civetries were used for diet analysis from the four habitats. These civetries were selected to save time and other resources. Sample civetries were selected based on the distance between the civetries (civetries at maximum distances were selected) and variation in the microhabitat surrounding the civetries. Using these criteria, four civetries in the farmlands, three civetries in the natural forest, two civetries in the commercial farm and two civetries in the urban areas were selected for fecal analysis. Fresh scats were collected from these representative civetries during July 2011–March 2014 and part of it was taken in polyethylene bags. Important information such as color, number of feces, appearance and main components of undigested visible materials were recorded during collection. These samples were labeled and transported to the laboratory for analysis.

Samples were washed with tap water and filtered through 1x1 mm^2 sieve to observe the items by naked eyes. The food items were easily identified based on the remains of the food such as bone, undigested meat, shells, claws, feathers, hair, bird beak, undigested legs, cartilages, skin and skull. The remains in the diet were used to infer the diet of civets. Plant parts such as cellulose materials, pulp, leaves, seeds, fruits, roots, stem and spine were used to differentiate the plants consumed by civets. Most of the food items were identified by naked eyes. The undifferentiated parts of the samples were dried, crushed, treated with acetone and examined by a stereo microscope. Doubtful contents were identified through comparison with reference materials from the animal's habitat and using the collection in the Natural Herbarium (Addis Ababa University, Ethiopia) and asking elderly people in the area for the fruit and plant types.

Dry bulk density, moisture content, pH, organic carbon and organic matter of the soil samples were determined for soils collected from civetry and non-civetry sites from the current study areas. For dry bulk density determination, a metallic cylindrical core sampler was used to collect soil samples. In the soil-core method, cylinders of known volume with sharpened edges were pressed or hammered into the soil, dug out and trimmed, whereupon their contents were weighed (Campbell and Henshall, 1991). Control soil sample was taken from a distance of 10 m from each civetry by considering same slope and vegetation condition. All samples were taken from the top soil at a depth of < 10 cm. Then the soil was collected in airtight plastic bag, labeled and stored in an area that prevents direct contact with sunlight. A single core sampler was used and hence the volume was the same for all samples. The soil sample was taken during the dry season to reduce level of error of the moisture content and bulk density (Kamara and Haque, 1987).

Laboratory analysis was carried out in Wondo Genet College of Forestry and Natural Resources soil laboratory. Soil samples were weighed using an electronic balance to 0.01 g accuracy within the first two days of sample labeled and oven dried at 105^{o}C for 48 hours (Kamara and Haque, 1987). Oven dried samples were weighed to get dry weight of the soil sample. During both measurements, the weight of container was subtracted and the net weight of each soil sample was used for calculation.

Soil samples for determination of soil organic carbon, soil organic matter and pH were collected in different containers from the top soil. About a kilogram of the soil sample was collected from each sample site both from civetry and non-civetry locations. These samples were prepared under shade at room temperature. Large particles (greater than 2 mm in diameter) were removed from soil samples. During the preparation, the soils were dried for three days, grounded (to homogenize the soil) and sieved in 0.5 mm sieve. Quantification of organic matter, organic carbon and measurement of pH were carried out from this soil.

For determination of soil organic carbon (SOC), dry combustion technique was used. In this technique, a high temperature was applied in a furnace. Collection and detection of evolved CO_2 was carried out (Tiessen and Moir, 1993). Soil organic matter was determined from organic carbon measurements. After determination of organic carbon content of soils, the values were converted to soil organic matter using conversion factor of 1.724, i.e. organic matter = organic carbon x 1.724 (Nelson and Sommers, 1996).

Data on scent marking by civets were collected from farmland, natural forest and urban areas. Sampling sites were searched extensively to locate the environmental sign-posts of the civets (Bekele Tsegaye *et al*., 2008a). Searching for scent marked sites was focused in all areas of the sample location, especially around the civetry sites and pathways. Transect lines were established based on random distribution along pathways. Geographical coordinates of each sign-post was recorded using GPS after identification. Investigation was carried out from transect line and circular plots around civetry locations. On each transect line, the investigation covered a width of 20 m on both sides of the pathway. Information such as distance from pathway, height at which the secretion was marked, remarking, marked species or objects, diameter of marked object at scent marked location, amount of the glandular secretion on sign-posts, condition of marked objects and GPS points were recorded. In circular plot survey, the area was marked at 50 m radius taking the civetry at the origin. All sign-posts within the circular plot were identified and the necessary information were recorded as in the case of transect line survey.

2.3. Data analyses

After counting the number of feces from each civetry during different seasons on a daily basis, calculations were carried out to know the number of civets belonging to each civetry. Mean, minimum and maximum number of civets in each civetry was calculated and then the population density was estimated for each habitat during different seasons. Mean number of individuals and standard error of the mean were calculated for each of the civetries in the study area. Mean number of individuals per civetry was estimated based on the total number of feces collected during the investigation period divided by the number of days of investigation as follows:

$$Nc = \frac{F}{d}$$

where, *Nc* is the mean number of individuals per civetry, *F* is the total number of feces per investigation period per civetry and *d* is the total number of days of the investigation.

Population size of civets in the whole study area is equal to the sum of the mean number of civets in all civetries in the sample sites, expressed as:

$$P = \sum_{i=1}^{n} Nc$$

where *P* is the population size of civets in the study area, *Nc* is the mean number of civets in each civetry during the study period and *n* is the number of civetries that was investigated.

Minimum population size in the study area was estimated by summing of the mean of the minimum number of civet(s) in each civetry during the study period as

$$Pmin = \sum_{i=1}^{n} nmin$$

where P_{min} is the minimum number of civets in the study area, n_{min} is the minimum number of civet(s) in each civetry and *n* is the number of civetry.

Maximum population of civets in the study area was estimated by summing the mean of maximum number of civet(s) in each civetry during the study period, i.e. the maximum number of feces counted in a single day during each month during the study period.

$$Pmax = \sum_{i=1}^{n} nmax$$

where P_{max} is the maximum number of civets in the study area, n_{max} is the maximum average number of civets in each civetry and n is the number of civetry.

Mean density of civets in the study area was estimated by dividing the mean number of civets by the extent of the area covered during the current investigation period expressed as:

$$D = \frac{P}{A}$$

where D is the density of civets in km^2 estimated in the study area, P is mean number of civets and A is the extent of the area covered during this investigation period. One-way ANOVA test was performed to compare the mean number of civets per civetry and population density between habitats and seasons.

All the formulas used above for calculation of civet numbers in each civetry and population size were derived by the researcher and will be published as new approach for estimating civet population from civetry.

For diet analysis, all identified items from the feces were considered as items eaten by civets. The fecal contents were presented as frequency of occurrence and relative percentage. Frequency of occurrence was the percentage of scat in which an item was found, which is expressed as:

$$Frequency\ of\ occurrence = \frac{Number\ of\ occurrence\ of\ each\ item}{Total\ number\ of\ scats} \times 100\%$$

Relative occurrence was the number of times the part of a given material was found as percentage of all items found and is calculated as:

$$Relative\ occurrence = \frac{Number\ of\ occurrence\ of\ each\ item}{Total\ number\ of\ items} \times 100\%$$

Food items with frequency of five or less were rejected from statistical analysis. Non-food items such as plastic materials were removed from analysis though their frequency was > 5. In a given season and habitat, food items with relative frequency of >5% was considered as common food item in the civet diet (Foster *et al.*, 2010). Food items having frequency of occurrence greater or equal to 40% was taken as a major item of civets.

Diet composition and preferences were compared between habitats and seasons. Important items of the diet were identified in each habitat type and season. One-way ANOVA, independent t test, χ^2 and mean comparison were performed among the variables to analyze feeding patterns of civets.

For soil analysis, dry bulk density of the soil sample was calculated after getting the mass of solid soil (Grossman and Reinsch, 2002) using the following equation:

$$db = \frac{Ms}{Vt}$$

where *db* is the dry bulk density of soil in g/cm^3, *Ms* is mass of oven dried soil measured in gram and *Vt* is the volume of the core sampler in cm^3.

Volume of the core sampler was calculated as:

$$Vt = Lc \times Ac$$

where *Vt* is the volume of core sampler in cm^3, *Lc* is the length of core sampler in cm and *Ac* is the area of the circle in the core sampler in cm^2. Replacing Πr^2 in the place of *Ac*, resulted the following equation:

$$Vt = Lc \times \pi r^2$$

where r is the radius of the circle at the base of the cylinder and Π is a constant. The length of the core was 10 cm, the radius was 3.75 cm and the value to the constant is 3.142. Therefore, the volume of the core is 441.84 cm^3. To all V*t*, this value was used.

Moisture content of the sampled soils was determined using gravimetric method. Moisture content was calculated from the mass of the wet and dry soil. The result was reported as percentage of moisture content using the following equation:

$$Wc = \frac{Mw - Md}{Md} \times 100\%$$

where *Wc* is the water content of a given soil sample in %, *Mw* is mass of wet soil sample in g and *Md* is mass of dry soil sample in g. Independent t-test was performed to compare mean water content between civetry and non-civetry soils.

Chi square test was used to compare density of sign-posts between transect lines and circular plots. Distribution map was prepared to see the most important areas for communication. Comparison was made between habitats and seasons using the mean density, mean weight of glandular secretion, selection of the sign-posts, average time taken to remark after removal of the scent from the marked location, height of objects where scent-marked and the distribution pattern along and around pathways and civetries.

All statistical analyses were performed using SPSS version 20.0 software (IBM Corp., 2011). Homogeneity of variance and normality of the distribution of all dependant data were verified prior to the analysis. In all cases, $\alpha = 0.05$ was taken.

3. RESULTS

3.1. Civetry

A total of 43 civetries were identified in the current study area. Among these, 21 were in farmland, 16 in natural forest, 4 in commercial farm and 2 in urban areas. Civetry density was 3.5, 3.2, 2.0 and 1.6 per km^2 in farmland, natural forest, urban and commercial farm habitats, respectively. Farmland area contained more civetries than the other three sample sites and the variation was statistically different ($t = 5.6$, $df = 3$, $p < 0.05$). There was higher probability of having civetries in farmland, at least by 9%, 75% and 98%, than in natural forest, urban and commercial farm areas, respectively (Figure 8).

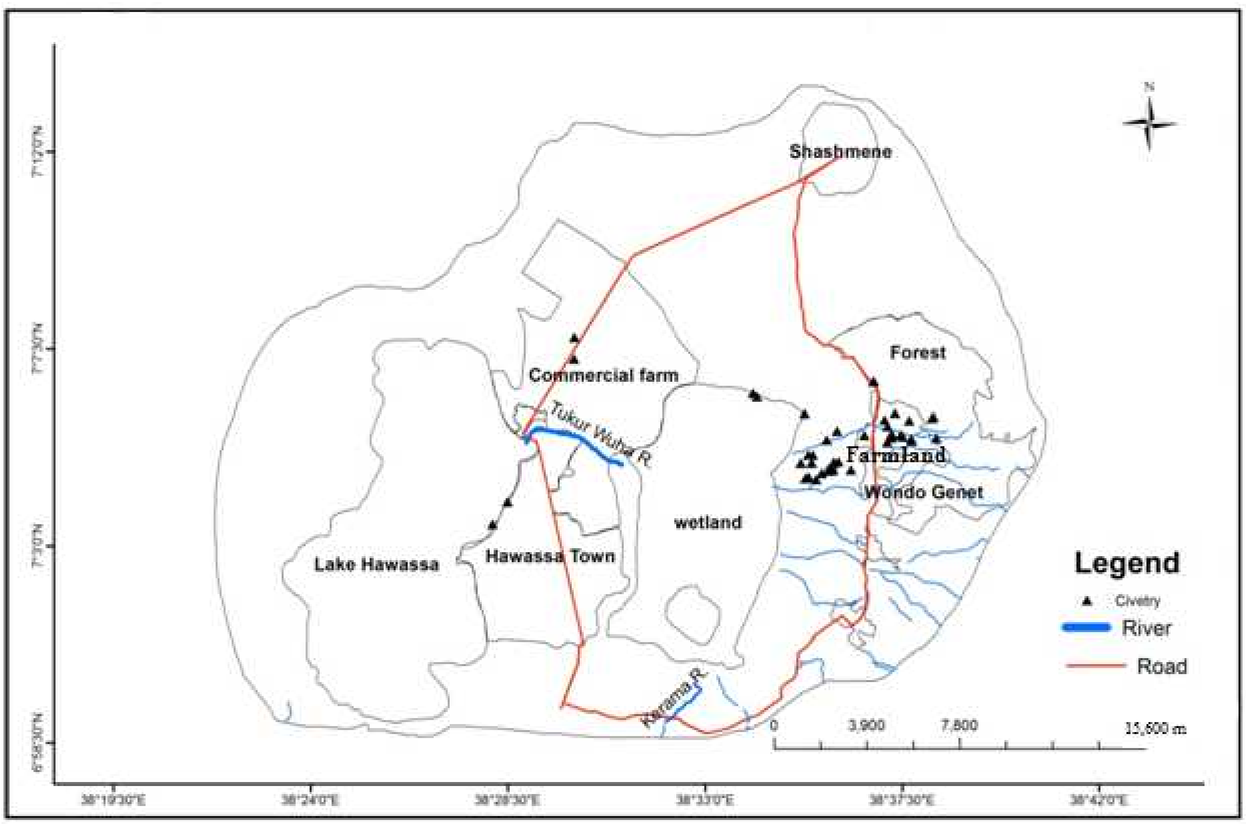

Figure 8. Distribution of the civetries in the present study area

Each civetry was used by civets for different periods of time. Overall, mean age of civetries in commercial farm, natural forest, farmland and urban area was 5.3±1.38, 3.8±0.67, 3.7±0.71 and 2.5±0.50 years, respectively. Civetry having 15 years of age was identified in farmland area located within sugarcane farm. Ninety three percent of the civetries had an age of less than or equal to eight years (Fig. 9). Eighteen percent of the civetries have an approximate age of 1 year, while 30% had two years.

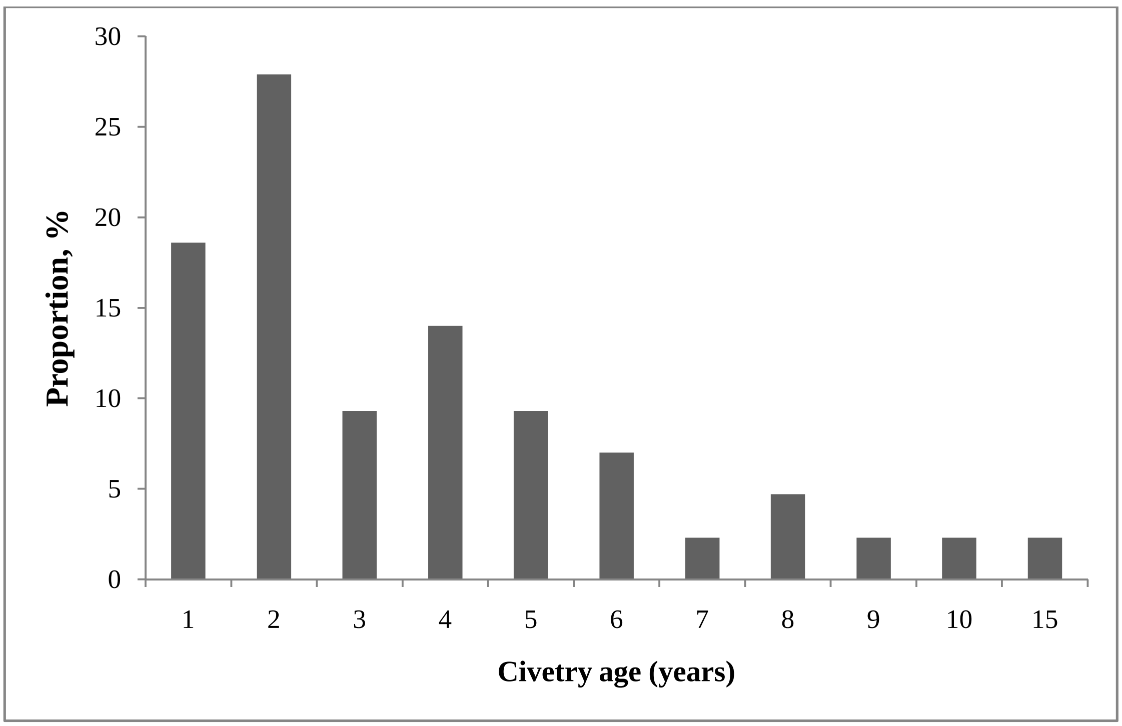

Figure 9. Age of civetries in the study area as revealed from the local people and the researcher

Location of the civetry in relation to wildlife track/pathways was significantly differed between habitats ($F = 5.86$, $df = 3$, $p < 0.05$). Multiple comparison tests revealed that the variation was due to the highest distance between the civetry and the wildlife track in the commercial farm. Comparisons between commercial farm and natural forest ((LSD $\alpha_1 = 0.001$), commercial farm and farmland (α_2 = 0.000) and commercial farm and urban habitat (α_3 = 0.006) were statistically significant. Civetries from the nearest wildlife tracks to each civetry were located at an average distance of 3.6 m, 4.9 m, 6.4 m and 16.3 m in urban area, farmland, natural forest and the commercial farm, respectively.

Overall, seventy four percent of the civetries were located at a distance less than 10 m from pathways (Fig. 10). From this, 21% of the civetries were located on the main road itself at a distance of zero meters. In the current study area, civetry having long distance from the nearest pathway was observed in commercial farm at a distance of 22 m.

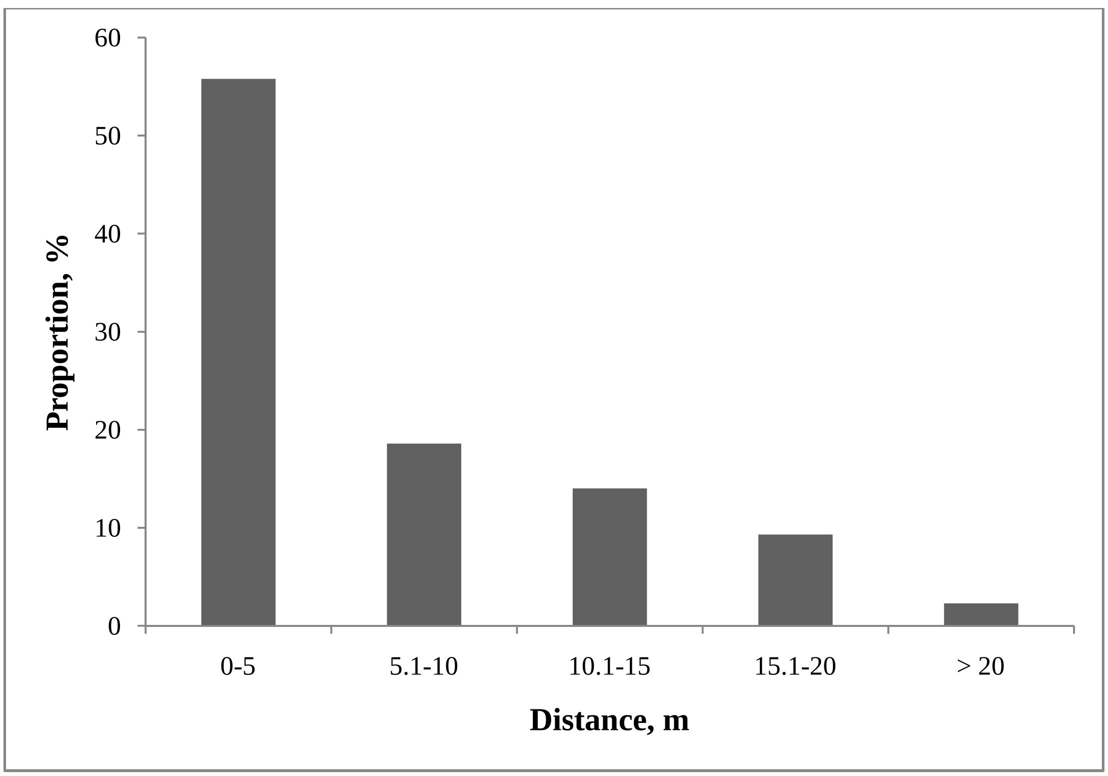

Figure 10. Proportion of civetry distance from the nearest wildlife track

The structure of vegetation surrounding civetries varied among dense forest (4.7%, n = 2), shore vegetation (4.7%, n = 2), maize (4.7%, n = 2), bushy (9.3%, n = 4), grassy (9.3%, n = 4), home garden (9.3%, n = 4), khat (9.3%, n = 4), bare land (16.3%, n = 7), plantation (16.3%, n = 7) and sugarcane (16.3%, n = 7). Thirty percent of the civetries were surrounded by agricultural crops such as maize, khat and sugarcane. Civetries were distributed along the densely forested vegetation structure to bare land on the main road.

African civets were observed to establish 81.4% of their civetries in open dry land along pathways, while 14% of the civetries were in semi-closed habitats. Only 4.6% of the civetries were recorded under canopy in a densely forested habitat. No civetries were observed in the interior of dense forest at a distance of more than 50 m from pathways.

Civets defecate in a clumped pattern in most of the occasions (72.1%). Adult civets accumulate their droppings over each other every night they defecate. Young and sub-adult civets preferred to defecate at a close proximity (less than 0.4 m) to the clumped adult feces. In a newly established civetry and civetries with young civet, scattered pattern of defecation was observed. During the current investigation, 28% of the civetries were observed with scattered pattern of defecation. In less than 5%, civetries with 2−4 different fecal clumps were seen in the same civetry (Fig. 11).

Figure 11. Multiple clumps of dung pile in the same civetry in one of the civetries located in sugarcane farm

African civets were trapped from different civetry sites by local trappers to sell them to civet farmers. A total of 52 civets were captured from the current study area during the last eight years as revealed by five local trappers. However, only 44 civets were sold to civet farmers and eight female civets were released at the location from where they were trapped. Twenty of the sold civets were captured from civetries located in farmland habitat, while 24 were captured from natural forests. Trapping rate was higher in natural forest habitat by 20% compared with farmland habitat. No civet was captured from urban and commercial farmland habitats during the study period.

Civetry sites were also used by other carnivores. Jackals feces were observed at seven occasions, while hyena and mongoose feces were observed at three occasions each. The feces of hyena were detected near to civetries at a distance of less than 40 cm, while the feces of jackals and mongoose were defected around a civetry at a distance of 1.5 meters.

3.2. Civet population

Overall, a mean of 2.4±0.02 civets were recorded using each civetry (Table 1). The number of civets used a civetry per night ranged between 0−14 individuals. Statistically significant variation was observed in the mean number of civets in each civetry across the study area ($F = 84.31$, $df = 42$, $p < 0.05$). More civetry users were recorded from civetries located in urban habitats with mean number of 5.1, and the civetries with few users (mean of 2.0 individuals) were observed in natural forest habitat (Table 1).

Table 1. Number of civets using each civetry in different habitats and seasons

Civetry site	Habitat	Number of civets (mean)				
		Wet season	Dry season	Minimum	Maximum	Annual
1	Natural forest	3.2 ± 0.14	1.9 ± 0.08	1.3 ± 0.3	4.3 ± 0.8	2.6 ± 0.1
2	Natural forest	2.8 ± 0.15	1.8 ± 0.09	0.6 ± 0.2	4.1 ± 0.7	2.3 ± 0.1
3	Natural forest	2.8 ± 0.11	1.7 ± 0.11	0.6 ± 0.3	4 ± 0.4	2.2 ± 0.1
4	Natural forest	2.3 ± 0.12	1.7 ± 0.09	0.6 ± 0.2	3.4 ± 0.4	2.0 ± 0.1
5	Natural forest	2.8 ± 0.12	1.4 ± 0.07	1.1 ± 0.4	3.3 ± 0.6	2.1 ± 0.1
6	Natural forest	1.7 ± 0.08	1.6 ± 0.08	0.6 ± 0.2	2.8 ± 0.2	1.6 ± 0.1
7	Natural forest	2.0 ± 0.13	1.5 ± 0.08	0.4 ± 0.2	3.1 ± 0.5	1.7 ± 0.1
8	Natural forest	2.3 ± 0.10	1.4 ± 0.07	0.8 ± 0.1	3.3 ± 0.4	1.8 ± 0.1
9	Natural forest	1.5 ± 0.09	1.6 ± 0.07	0.6 ± 0.2	2.8 ± 0.2	1.6 ± 0.1
10	Natural forest	1.9 ± 0.10	1.3 ± 0.06	0.4 ± 0.2	2.8 ± 0.4	1.6 ± 0.1
11	Natural forest	1.8 ± 0.11	1.1 ± 0.06	0.4 ± 0.2	2.6 ± 0.4	1.5 ± 0.1
12	Natural forest	1.9 ± 0.11	1.5 ± 0.09	0.5 ± 0.1	2.9 ± 0.3	1.7 ± 0.1
13	Natural forest	5.4 ± 0.25	2.0 ± 0.11	1.4 ± 0.6	6.3 ± 1.9	3.7 ± 0.2
14	Natural forest	2.5 ± 0.12	1.7 ± 0.1	0.7 ± 0.2	3.8 ± 0.4	2.1 ± 0.1
15	Natural forest	1.8 ± 0.10	1.3 ± 0.07	0.4 ± 0.21	2.8 ± 0.4	1.6 ± 0.1
16	Natural forest	1.9 ± 0.11	1.3 ± 0.08	0.4 ± 0.2	2.8 ± 0.3	1.6 ± 0.1

17	Farmland	3.2 ± 0.18	2.5 ± 0.15	0.9 ± 0.26	5.3 ± 0.66	2.9 ± 0.1
18	Farmland	1.5 ± 0.09	1.4 ± 0.10	0.2 ± 0.12	2.8 ± 0.19	1.5 ± 0.1
19	Farmland	1.3 ± 0.06	1.4 ± 0.08	0.6 ± 0.12	2.3 ± 0.18	1.3 ± 0.1
20	Farmland	1.3 ± 0.08	1.2 ± 0.07	0.3 ± 0.10	2.50 ± 0.25	1.2 ± 0.1
21	Farmland	1.6 ± 0.09	1.2 ± 0.07	0.5 ± 0.18	2.4 ± 0.31	1.4 ± 0.1
22	Farmland	1.8 ± 0.09	1.3 ± 0.08	0.4 ± 0.19	2.8 ± 0.28	1.5 ± 0.1
23	Farmland	1.7 ± 0.08	1.7 ± 0.09	0.50 ± 0.20	2.9 ± 0.31	1.7 ± 0.1
24	Farmland	1.5 ± 0.10	1.5 ± 0.09	0.4 ± 0.07	2.6 ± 0.26	1.5 ± 0.1
25	Farmland	3.7 ± 0.19	3.2 ± 0.19	0.9 ± 0.21	6.6 ± 0.74	3.4 ± 0.1
26	Farmland	2.7 ± 0.15	2.8 ± 0.16	1.3 ± 0.40	4.9 ± 0.79	2.7 ± 0.1
27	Farmland	3.0 ± 0.17	2.1 ± 0.11	1.1 ± 0.30	5.1 ± 0.62	2.5 ± 0.1
28	Farmland	4.1 ± 0.22	2.8 ± 0.15	1.1 ± 0.21	5.9 ± 0.81	3.4 ± 0.1
29	Farmland	3.7 ± 0.18	2.1 ± 0.11	1.2 ± 0.34	5.2 ± 0.74	2.9 ± 0.2
30	Farmland	3.6 ± 0.19	2.6 ± 0.14	1.2 ± 0.28	5.7 ± 0.72	3.1 ± 0.2
31	Farmland	3.4 ± 0.19	2.2 ± 0.11	1.2 ± 0.33	4.9 ± 0.60	2.8 ± 0.1
32	Farmland	1.8 ± 0.10	1.8 ± 0.10	0.6 ± 0.13	3.4 ± 0.33	1.8 ± 0.1
33	Farmland	3.2 ± 0.18	2.5 ± 0.13	1.0 ± 0.18	5.1 ± 0.62	2.8 ± 0.1
34	Farmland	3.1 ± 0.16	2.6 ± 0.13	0.9 ± 0.06	5.1 ± 0.54	2.8 ± 0.1
35	Farmland	3.5 ± 0.17	3.1 ± 0.13	1.1 ± 0.31	5.8 ± 0.48	3.3 ± 0.1

36	Farmland	3.0 ± 0.15	2.7 ± 0.14	1.0 ± 0.37	5.1 ± 0.60	2.9 ± 0.1
37	Farmland	1.4 ± 0.09	1.2 ± 0.10	0.1 ± 0.06	2.8 ± 0.23	1.3 ± 0.1
38	Commercial farm	4.4 ± 0.20	2.9 ± 0.17	1.1 ± 0.30	6.9 ± 0.83	3.7 ± 0.2
39	Commercial farm	4.5 ± 0.20	2.0 ± 0.12	1.1 ± 0.48	1.1 ± 1.16	3.3 ± 0.2
40	Commercial farm	2.8 ± 0.13	1.4 ± 0.10	07 ± 0.31	4.3 ± 0.48	2.1 ± 0.1
41	Commercial farm	3.5 ± 0.20	1.5 ± 0.09	0.8 ± 0.26	5.0 ± 1.19	2.5 ± 0.1
42	Urban area	5.4 ± 0.23	5.3 ± 0.24	1.8 ± 0.47	9.1 ± 0.13	5.5 ± 0.2
43	Urban area	5.0 ± 0.28	4.6 ± 0.27	0.3 ± 0.12	9.7 ± 0.61	4.8 ± 0.2

All civets did not use civetries every day. In some days, civetries were observed without fresh droppings (6.5% of the civetries), and in other days with more fresh droppings. Variation on the mean number of civetry users was observed between habitats ($F = 517.8$, $df = 3$, $p < 0.05$). In the urban habitat, the number of civets that use each civetry was higher than other habitats (Fig. 12). Relatively, few civets used each civetry in the natural forest habitat. A mean of 5.1±0.08 civets were observed using each civetry in the urban area, while a mean of 2.9±0.05, 2.3±0.2 and 2.0±0.3 civets used each civetry in the commercial farm, farmland and natural forest areas, respectively. Civetry users were not uniformly distributed between civetries even those located within the same habitat. For example, civetries 17 and 18 were located in farmland area (< 200 m distance), but the mean number of civets using civetry 17 were almost double than those using civetry 18 (Table 1).

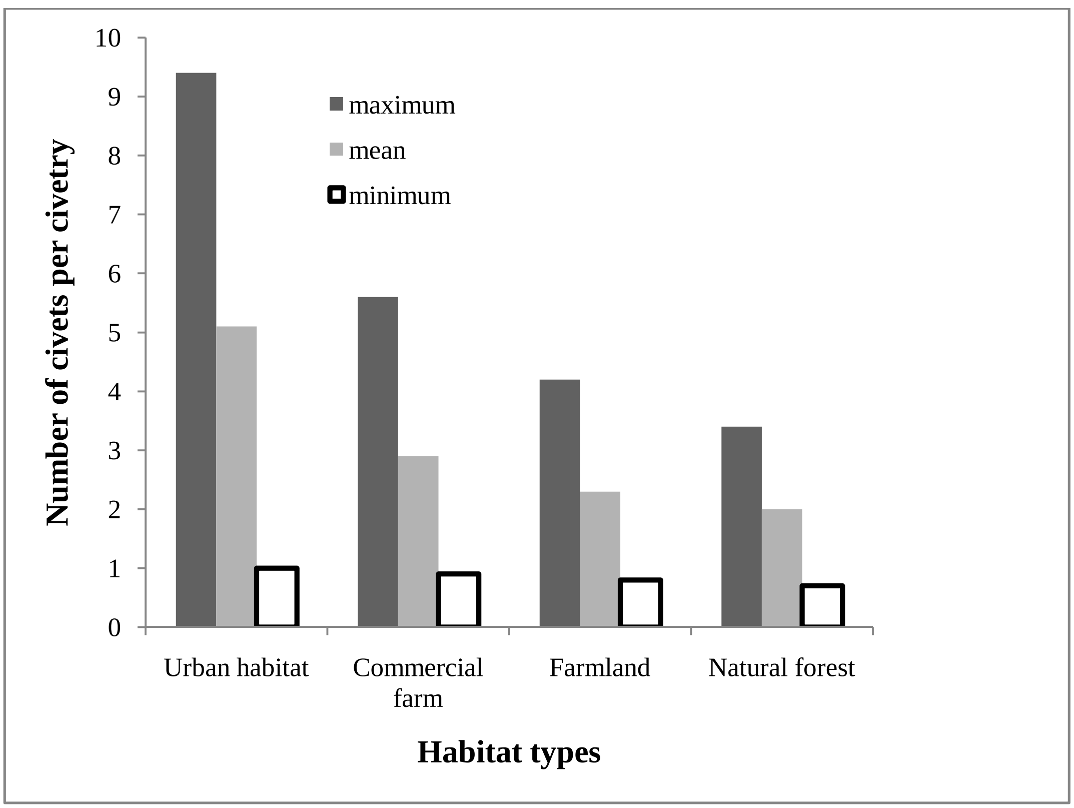

Figure 12. Number of civets per civetry between different habitats and seasons

Mean number of civetry visitors have fluctuated with season (F = 299.4, df = 1, $p < 0.05$). In the overall study area, a mean of 3.5±0.04 civets were recorded using each civetry during the wet season, while a mean of 2.6±0.04 civets used each civetry during the dry season. Few civetry users were recorded in natural forest habitat with mean of 2.4 and 1.6 civets per civetry during wet and dry seasons, respectively. During the wet season, mean of 2.6 individuals were recorded in civetries located in the farmland, while only 2.1 individuals per civetry were recorded during the dry season. In all study habitats, the mean number of civets using civetry was more during the wet season (Fig. 13).

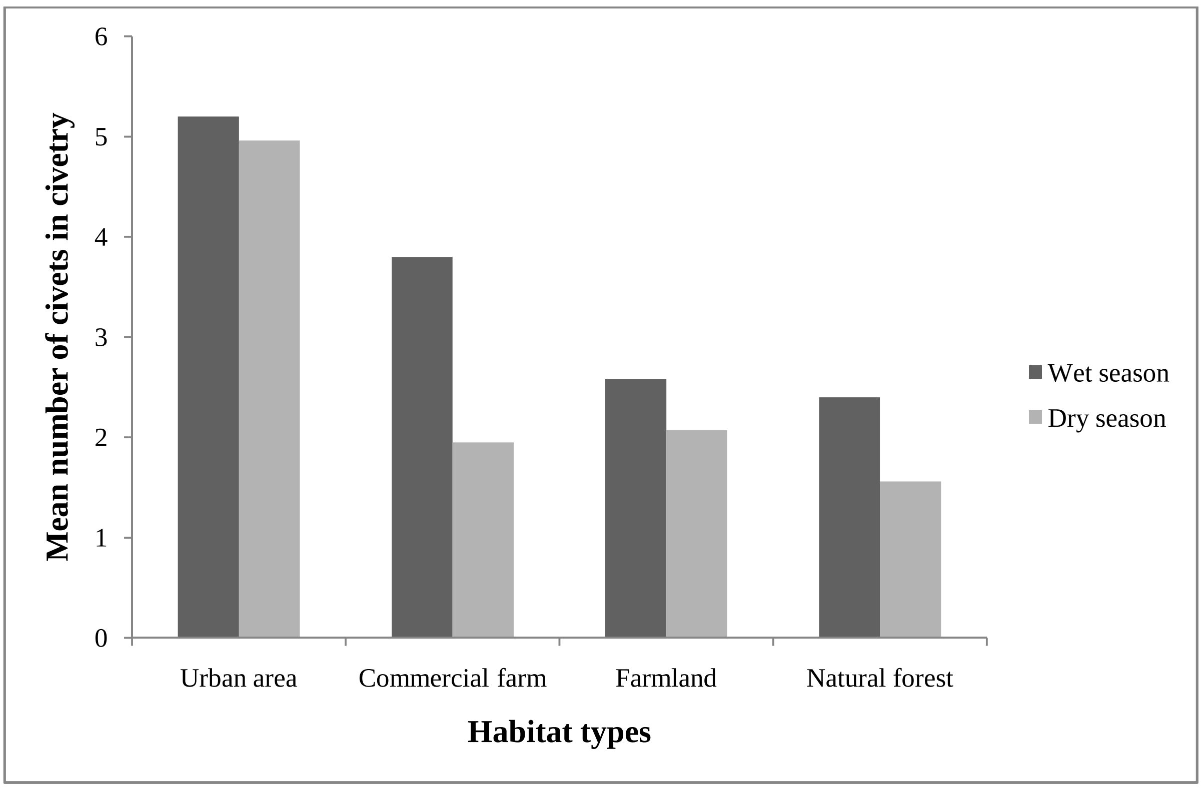

Figure 13. Mean number of civets that used civetries during wet and dry seasons

Population sizes of the African civets estimated for the four habitats during the wet and dry seasons are presented in Table 2.

Table 2. Estimated population size of the African civets in the study area

Habitat type	Population size								
	Wet season			Dry season			Annual		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Commercial farm	5.9	27.9	15.2	1.6	16.9	7.8	3.8	22.4	11.5
Farmland	19.4	97.3	54.1	13.3	80.8	43.5	16.3	89.0	48.8
Natural forest	13.6	67.5	38.6	7.9	42.5	24.9	10.5	55.0	31.8
Urban	2.1	19.3	10.4	2.0	18.4	9.9	2.1	18.8	10.2
Total	41.0	212.0	118.3	24.8	158.6	86.1	32.7	185.5	102.3

The estimated population size ranged from 1.6 civets in commercial farm during the dry season to 97.3 civets in farmland during the wet season. During the wet season, a mean of 54.1, 38.6, 15.2 and 10.4 civets were estimated in farmland, natural forest, commercial farm and urban area, respectively. During the dry season, the population size of civets was less in all habitats and a mean of 43.5, 24.9, 7.8 and 9.9 civets were estimated in farmland, natural forest, commercial farm and urban area, respectively.

Population density of the African civet in the present study area ranged from 0.023 civets/hectare (2.3 civets/km^2) to 0.128 civets/hectare (12.8 civets/km^2) with a mean density of 0.071 civets/hectare (7.1 civets/km^2). Densities between minimum, maximum and mean population of civets showed statistically significant variation ($F = 14.46$, $df = 2$, $p < 0.05$). In the commercial farm, the smallest mean density of civets was recorded (4.6 civets/km^2), while the largest mean density was in urban habitat (10.2 civets/km^2). Relatively, farmland areas (8.3 civets/ km^2) contained higher density than natural forest habitats (6.4 civets/ km^2) (Table 3).

Table 3. Estimated population density of the African civet in the study area

Habitat type	Population density/ha								
	Wet season			Dry season			Annual		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Commercial farm	0.021	0.112	0.061	0.006	0.068	0.031	0.015	0.090	0.046
Farmland	0.032	0.162	0.090	0.022	0.135	0.073	0.027	0.148	0.083
Natural forest	0.027	0.135	0.077	0.016	0.085	0.050	0.021	0.110	0.064
Urban	0.021	0.193	0.104	0.020	0.184	0.099	0.021	0.188	0.102
Total	0.028	0.146	0.082	0.017	0.109	0.059	0.023	0.128	0.071

Population density of civets in the current study area showed spatial and seasonal variations across the habitats studied. During the wet season, the density of civets ranged from a minimum of 2.8 to 14.6 civets/km^2, with average density of 8.2 civets/km^2. Mean civet density in urban area (10.4 civets/km^2) and farmland habitat (9.0 civets/km^2) was higher than in the natural forest (7.7 civets/km^2) and commercial farm (6.1 civets/km^2) areas during the wet season (Fig. 14).

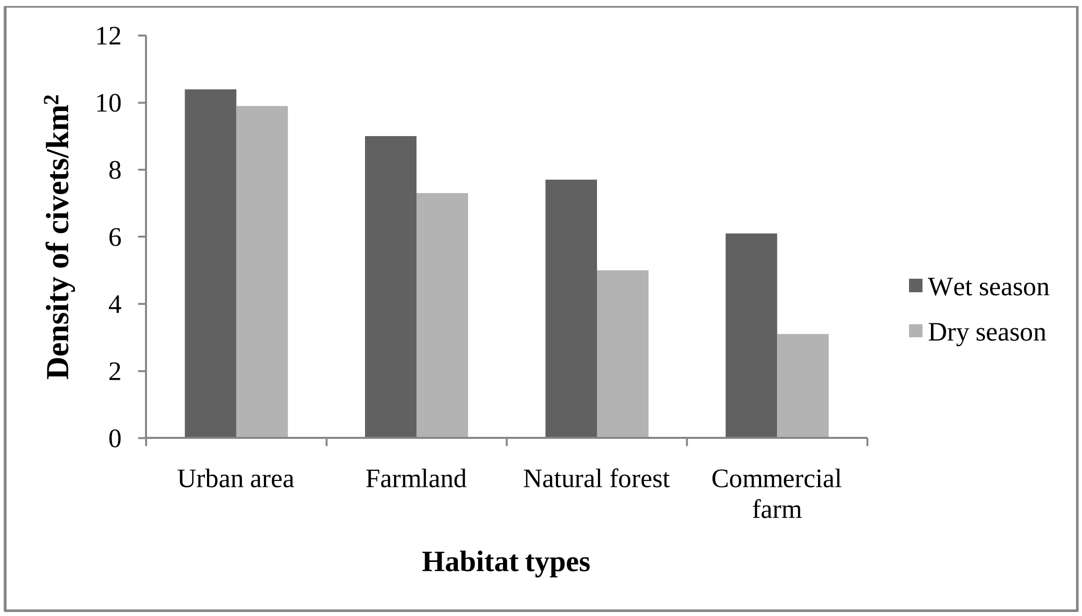

Figure 14. Density of civets in different habitats during the wet and dry seasons

During the dry season, the density of civets was low in all habitats. In the commercial farm, population density was reduced from 6.1−3.1 civets/km^2 during the dry season, while in natural forest the density was reduced from 7.7─5.0 civets/km^2. But, insignificant density decrease was observed in urban areas (from 10.4─9.9 civets/ km^2) and farmland habitat (from 9.0─7.3 civet/km^2). The variation in civet density between wet and dry season was only 5% in the urban habitat (Table 3). During the wet and dry seasons, the distribution of the estimated minimum, maximum and mean densities of civets showed statistically significant variation ($F = 28.9$, $df = 2$, $p < 0.05$) across the four habitats.

3.3. Feeding ecology of civets

A total of 2148 feces were collected and analyzed from farmland (n = 819), natural forest (n = 723), urban (n = 333) and commercial farm (n = 273) habitats. More than 52% (n = 1117) of these fecal materials were collected during the wet season. The shape of civet feces was in tubes and cylindrical. It was one long complete piece or broken, segmented and/or folded into many parts. Colors of feces varied: dark (23.7%, n = 482), brown (22.2%, n =451), red (16.7%, n = 340), green (14.8, n = 300), white (13.3%, n = 270) and yellow (5.2%, n = 106). Mixed colored feces such as green with red and red with brown were also observed in 2.7% (n = 54) and 1.5% (n = 30) of the feces, respectively. The proportion of fecal color varied from habitat to habitat and with seasons. In commercial farm, white (38.1%, n = 104) and dark (29.7%, n = 81) colored feces were common, while only few feces had green color (3.3%, n = 9). Green (24.8%, n = 203) and dark (21%, n = 172) colored feces were commonly observed in farmland, while 10.4% (n = 85) of the feces were yellowish. In the natural forest, brown (48.3%, n = 349) and red (21.2%, n = 153) colored feces were common, while in urban areas dark (28.2%, n = 94) and whitish (18.9%, n = 63) colored feces were common.

Overall, the appearances of 81% of the collected feces were solid, while 20% were semi-solid. More than 84% of the feces collected from commercial farm had solid appearance. In the natural forest, 81% of the feces had a solid appearance. In urban and farmland areas, 80% of the feces had a solid appearance.

The proportions of main undigested component in the fecal materials varied between items (χ^2 = 542.5, df = 12, $p < 0.05$). In the farmland area, 470 fecal samples were observed with a single food item composing more than 50% of the total biomass of the diet. In this habitat, *Persea americana* was observed in 24.5% of the fecal samples as the main undigested component followed by maize (12.3%), *Ficus* spp. (11.7%) and *C. africana* (11.3%). Grass, hair and insects were seen as the main undigested components in 9.4%, 7.4% and 6.8% of the feces, respectively. *Musa* sp., *Dracaena steudneri*, *Carcia papaya*, bone and meat, *Pisidium guajava* and *Casmirao edulis* were other components observed as the main undigested parts of feces. In the commercial farm, maize, insects, *Ficu*s spp., hair, *C. africana*, bone and meat, grass and *D. steudneri* were observed as the main undigested components in 52% of the collected feces. *Ficus* spp., *C. africana*, hair, bone and meat, insects, grass, *P. americana*, *Z. mays* and *D. steudneri* were seen as the main components in 51.4% of collected feces from the natural forest. In the urban area, bone and meat, *Ficus* spp., *Z. mays*, *P. americana*, *Musa* sp., *C. edulis*, *C. africana*, insects, hair, grass, *C. papaya* and *P. guajava* were recorded as main components in 47.4% of the feces.

Forty one food items (other than non-food items such as plastic, sand, ash, soil and dry wood) were identified from the feces of civets in the current study area and presented in Table 4. Almost 59% of the civets' diet were mainly composed of plant parts such as fruits and grains (36.9%), leaves and shoots (18.3%), roots and tubers (3.4%). Selection of civets between these parts of plants varied significantly ($\chi^2 = 30.03$, df = 2, $p < 0.05$) with higher preference to fruits. Five most dominant fruits and grains in the diet were *P. americana*, *Ficus* spp., *C. africana*, *Z. mays* and *D. steudneri*. No fruit contributed more than 10% of the overall diet.

Table 4. Food items of civet identified from the current study area (1 = Commericail farm, 2 = farmland, 3 = natural forest and 4 = urban area)

Food items Part eaten	Scientific name	Relative occurrence in diet	Habitats where parts identified
Fruits and grains			
Avocado	*Persea americana*	8.2	2, 3 and 4
Fig trees	*Ficus* spp.	7.8	1, 2, 3 and 4
Cedar tree	*Cordia africana*	6.3	1, 2, 3 and 4
Maize	*Zea mays*	3.5	1, 2, 3 and 4
Dracaena	*Dracaena steudneri*	2.3	1, 2 and 3
Banana	*Musa* sp.	2.1	2 and 4
Palm tree		1.7	2, 3 and 4
Papaya	*Carcia papaya*	1.7	2
Guava	*Psidium guajava*	1.2	2 and 3
White sapote	*Casmiroa edulis*	1.1	2 and 4
Mango	*Mangifera indica*	0.5	2
Podocarp	*Dovyalis caffra*	0.2	2 and 3
Pumpkin	*Podocarpus falcatus*	0.2	3
	Cucurbita sp.	0.1	2 and 3
	Solanium nigra	-	3
Leaves and shoots			
Grasses	family Poaceae	10.9	1, 2, 3 and 4
Vegetables		2.4	2, 3 and 4
Sugarcane	*Saccharum spp.*	2.6	2 and 3
Herbs		0.7	1, 2, 3 and 4

‘Enset’	*Ensette vetricosum*	0.7	2 and 3
Eucalyptus	*Eucalyptus* sp.	0.5	2 and 3
Shrubs		0.3	1, 2, 3 and 4
Acacia	*Acacia* spp.	0.2	1
Coffee	*Coffea arabica*	-	2
Khat	*Catha edulis*	-	2
Roots and tubers			
‘Kocho’	Fermented product	1.2	2
Taro	*Colocasia esculenta*	0.9	2, 3 and 4
Potato	*Solanum tuberosum*	0.6	2 and 4
Carrot	*Daucus carota*	0.3	2 and 4
Sweet potato	*Ipomoea batatas*	0.4	2
Mammals			
Bone and meat		4.5	1, 2, 3 and 4
Rodent	order Rodentia	6.6	1, 2, 3 and 4
Hair*		2.2	1, 2, 3 and 4
Birds			
Egg		3.5	1, 2, 3 and 4
Bird	Class Aves	2.7	1, 2, 3 and 4
Chicken	*Gallus gallus*	0.2	2, 3 and 4
Fishes		2.8	4

Invertebrates			
Insects	Class Insecta	13.8	1, 2, 3 and 4
Snail	*Achatina fulica*	3.2	1, 2, 3 and 4
Millipedes	Class Diplopoda	1.5	1, 2, 3 and 4
Worm		0.6	2, 3 and 4
Non-food items			1, 2, 3 and 4

* Hair is not diet item but it indicates the occurrence of mammals and scavenging behavior. Thus, the meaning of hair should be considered as an indication of the presence of unidentified mammals in the diet of civets.

Fruits, insects, small mammals and grass were the four main food items, which constituted 75% of civet diet. Overall, fruits and grains (mainly *P. americana*, *C. africana*, *Ficus* spp. and *Z. mays*) constituted the major diet of civets with relative occurrence of 36.9%. Fruits and grains of 15 species of plants were consumed by civets in the study area. Fruits of seven indigenous plant species (*Ficus* spp., *D. steudneri*, *C. africana*, *Phoneix rectilina*, *Dovyalis caffra*, *Solanium nigra* and *Podocapus falcatus*) with relative occurrence of 16.8% and fruits of eight domestic plants (*P. americana*, *Z. mays*, *Musa* sp., *Psidium guajava*, *Carcia papaya*, *Casmiroa edulis*, *Cucurbita* sp. and *Mangifera indica*) with relative occurrence of 18.4% were recorded.

Insects (relative occurrence 13.8%), mammals (relative occurrence 13.3%) and grass (relative occurrence 10.9%) were the other preferred food resources (Table 4). Grasses of various species were identified from the feces of civets. Grass with occurrence of 10.9% was among the common diet of civets. Vegetables such as *Lycopersicon esculentum*, *Piper* sp. and *Brassica* sp. composed of 2.4% of the diet. Roots and tubers of *Colocasia esculenta*, potato, *Dacota carota* and *Impoma batatas* were also observed in rare occasions. Civets fulfilled 41% of their diet requirements by including animals in the diet. Remains of invertebrates (19.1%), mammals (13.3%), birds (6.6%) and fish (2.8%) were found from the feces. Insects (13.8%) were the main components of civet diet among invertebrates, followed by snail (3.2%) and millipede (1.5%). Among mammals, rodents were the common diet of civets with 6.6% of occurrence, while eggs of birds were common from avian group. The major diet of civets is plants compared to animals; however, diet preference by civets between plant and animal sources did not vary significantly ($\chi^2 = 3.24$, df = 1, $p > 0.05$).

Fruits of *Ficus* spp., *C. africana* and *Z. mays* (grain) were identified from the feces of civets collected from four habitats, while fruits of *C. papaya*, *M. indica*, *P. falcatus* and *S. nigra* were identified only from a single habitat. *Persea americana*, *Ficus* spp. and *C. africana* fruits were the common diet of civets with relative occurrence of 8.2%, 7.8% and 6.3%, respectively, while fruits of *M. indica*, *D. caffra*, *P. falcatus*, *Cucurbita* sp. and *S. nigra* were included in the diet of civets rarely.

Fourteen items (34.4%) were common to all the four habitats, while 11 of the 41 items were restricted to a single habitat. *Persea americana*, *D. steudneri*, vegetables, *C. esculenta*, chicken and worms were identified from all the three habitats, but not from the commercial farm. Ten items of the diet were identified from two habitats. Mammals, birds (except chicken) and invertebrates (except worms) were observed in feces collected from all habitats. Fishes were restricted to only urban habitats.

Diet preference between the groups (fruits, leaves and shoots, roots and tubers, mammals, birds, fish and invertebrates) showed statistically significant variation ($F = 4.3$, $df = 6$, $p < 0.05$). Post hoc multiple comparison between groups by LSD test revealed the absence of significant variation on the diet preference between fruits and leaves and shoots (LSD, $\alpha = 0.142$), fruits and mammals (LSD, $\alpha = 0.080$) and fruits and invertebrates (LSD, $\alpha = 0.282$). However, civets preferred fruits more than roots and tubers (LSD, $\alpha = 0.008$), birds (LSD, $\alpha = 0.008$) and fish (LSD, $\alpha = 0.004$). Among animals, invertebrates were the more preferred diet than birds (LSD, $\alpha = 0.046$) and fish (LSD, $\alpha = 0.019$), but the level of preference between invertebrates and mammals was not significantly different (LSD, $\alpha = 0.420$).

During the wet season, 40 food items (other than non-food items) were identified from the feces of civets. Fruits of different species of plants constituted the main diet of civets with relative occurrence of 32.9%, while mammals (15.1%), insects (14%) and grass (12.6%) contributed a significant portion of the civet diet during this season. Out of these 14 species of fruits and grains consumed by civets, only six of these items (*P. americana*, *Z. mays*, *Ficus* spp., *D. studeneri*, *C. africana* and *Musa* sp.) contributed 79% of the fruit diet during the wet season. Only 21% of fruit diet contributed by eight species of fruit plants (Table 5). *Persea americana* (7%) and *Z. mays* (5.9%) were grouped as common diet of civets from fruits, while grasses were common among leaf and shoots. Bone and meat (6%) and rodents (5.1%) were common from mammals, and insects (14%) were the common diet of civets among invertebrates during the wet season.

During the dry season, most food items (36.8%) - *P. americana* (7% to 9.2%), *Ficus* spp. (4.3% to 10.5), *C. africana* (2.9% to 8.9%), vegetables (2.1% to 2.6%) and rodents (5.1% to 8%)

showed increase in the percentage composition in the civet diet. Twelve food items such as eucalyptus, shrubs, *Acacia*, egg, birds, fish and others did not show any change in the composition during the wet and dry seasons. *Zea mays*, *D. stuedneri*, *Musa* sp., *P. guajava*, *C. papaya*, grasses, herbs, enset, taro, bone and meat, insects and snail composition was reduced in the diet during the dry season. Fruits of *Ficus* spp. (10.5%), *P. americana* (9.2%), *C. africana* (8.9%), grasses (9.3%), rodents (8%) and insects (13.5) were the common diet of civets, during the dry season.

Table 5. Seasonal food composition and selection by civets in the study area

Part eaten	Wet season		Dry season	
	Frequency (n)	Relative %	Frequency (n)	Relative %
Fruits				
P. americana	345	7.0	538	9.2
Z. mays	291	5.9	78	1.3
Ficus spp.	214	4.3	614	10.5
D. stuedneri	179	3.6	66	1.1
C. africana	145	2.9	523	8.9
Musa sp.	129	2.6	100	1.7
P. guajava	97	2.0	26	0.4
C. papaya	92	1.9	86	1.5
Palm	63	1.3	115	2.0
C. edulis	39	0.8	85	1.5
M. indica	18	0.4	31	0.5
D. caffra	11	0.2	12	0.2

P. falcatus	4	-	15	0.3
Cucurbita sp.	2	-	11	0.2
S. nigra	0	0	8	0.1
Leaf and shoot				
Grasses	623	12.6	543	9.3
Vegetables	101	2.1	155	2.6
Sugarcane	100	2.0	177	3.0
Herbs	48	1.0	22	0.4
E. vetricosum	44	0.9	29	0.5
Eucalyptus	25	0.5	32	0.5
Shrubs	18	0.4	16	0.3
Acacia	12	0.2	9	0.2
C. arebica	4	-	1	-
Catha edulis	3	-	5	-
Roots and tubers				
"Kocho"	59	1.2	68	1.2
C. esculenta	57	1.2	44	0.8
S. tuberosum	20	0.4	44	0.8
D. carota	15	0.3	14	0.2
I. batatas	6	0.1	41	0.7
Animals				
Mammals				
Bone and meat	295	6.0	79	1.4
Rodent	249	5.1	467	8.0

Hair	195	4.0	249	4.3
Birds				
Egg	159	3.2	186	3.2
Bird	131	2.7	153	2.6
G. gallus	6	0.1	11	0.2
Fish	143	2.9	161	2.8
Invertebrates				
Insects	688	14	788	13.5
Snail	204	4.1	148	2.5
Millipedes	77	1.6	79	1.4
Worm	28	0.6	36	0.6

In the commercial farm, 16 food items were identified from civet diet (Fig. 15). Forty six percent of the diet is composed of fruits of *Z. mays* (16%), *C. africana* (13.1%), *Ficus* spp. (12.7%) and *D. stuedneri* (4.1%). In this habitat, fruits of three indigenous plants and *Z. mays* were identified. *Zea mays* was observed in 65.6% of the collected scats (relative occurrence 16%) and it was the most common diet. There was significant variation in the selection of fruits over other diets by civets in this habitat ($F = 15.38$, $df = 4$, $p < 0.05$). Multiple comparison using LSD test showed the variation was due to high preference of fruits over other food items such as mammals (LSD, $\alpha = 0.003$), invertebrates (LSD, $\alpha = 0.003$), leaves and shoots (LSD, $\alpha = 0.002$) and birds (LSD, $\alpha = 0.001$).

Mammals including rodents, hair, bone and meat (18.3%), invertebrates (15.7%), leaf and shoots of plants (12%) constituted major portion of the diet of civet next to fruits. Remains of birds were identified from 36% of the scats. Leaves of *Acacia* were observed as a civet diet in this habitat only composing 1.9% of the diet. Civets consumed 60% of their diet from plants and the remaining portion from animals in this habitat. Stone, plastic materials and aluminum foil were observed in 9.5% of the scats.

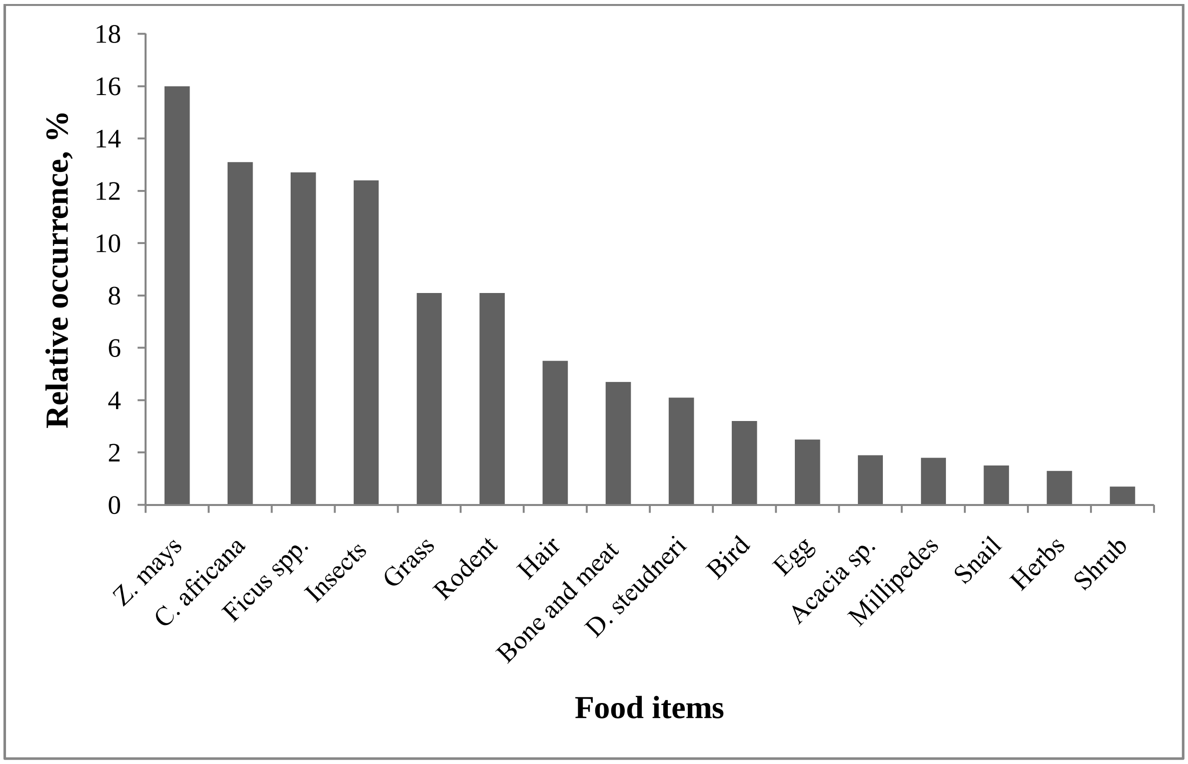

Figure 15. Food items identified from the scats of civets in the commercial farm area (non-food items are omitted from the analysis)

Seasonal variation was not observed in the number of food items included in the diet of civets in this habitat. Sixteen and 15 food items were identified in the scats of civets during the wet and dry seasons, respectively. Herb was not included in the diet during the dry season. Variation was observed in the relative occurrence between items. Composition of seven food items (*Z. mays*, grass, *D. steudneri*, bone and meat, herbs, *Acacia* and snail) were reduced during the dry season. For instance, the composition of *Z. mays* changed from 25.8% during the wet season to 8.8% during the dry season. Composition of egg, millipede and shrub were not changed in the diet of civets during both seasons. But, the composition of six food items (*Ficus* spp., *C. africana*, insects, rodents, hair and bird) showed an increase in proportion in the diet of civets during the dry season (Fig. 16).

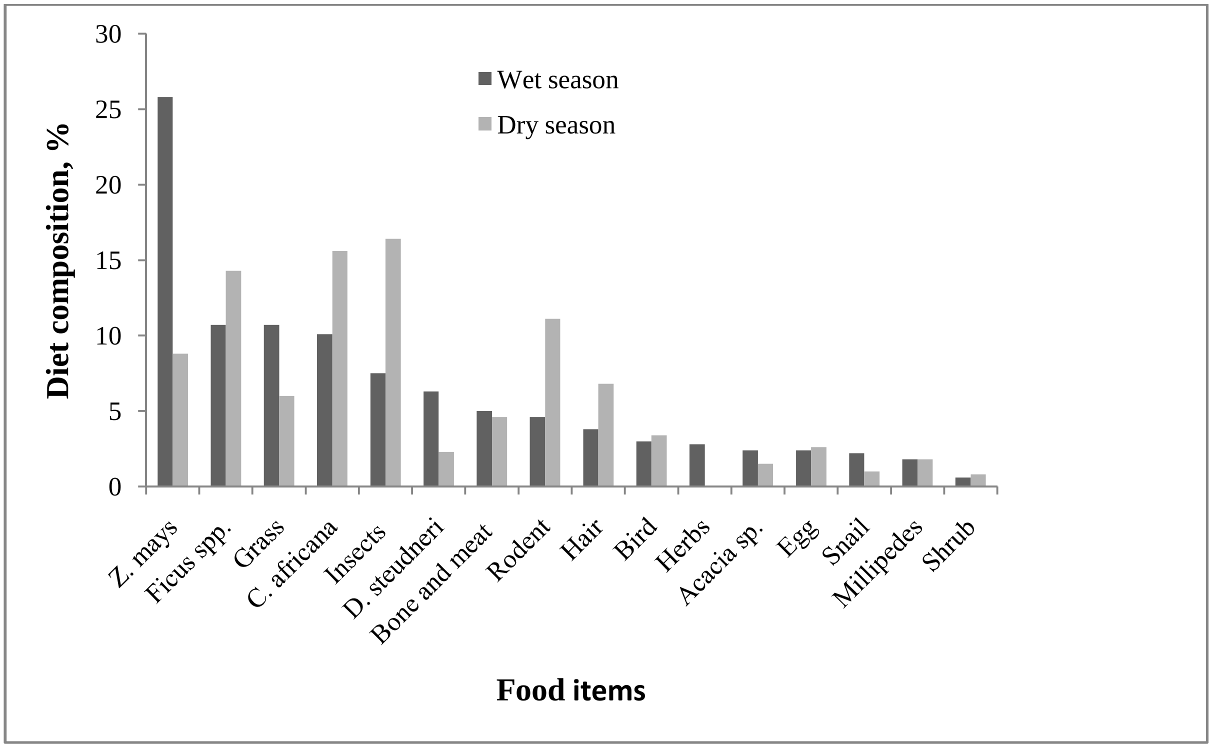

Figure 16. Diet composition of civets from the commercial farm during the wet and dry seasons

Zea mays (25.8%), *Ficus* spp. (10.7%), grasses (10.1%), *C. africana* (10.1%), insects (7.5%), *D. steudneri* (6.3%) and bone and meat (5%) were the common food items of civets during the wet season. Among these, *Z. mays* was the major diet of civets with the occurrence in 89.9% of the scats. Insects (16.4%), *C. africana* (15.6%), *Ficus* spp. (14.3%), rodents (11.1%) and *Z. mays* (8.8) were the common food items of civets during the dry season. Among these, insects, *C. africana*, *Ficus* spp., rodents and *Z. mays* were identified from 75.4%, 71.6%, 65.7%, 50.7% and 40.3% of scats, respectively, and they constituted the major diet of civets during the dry season.

In the farmland, 37 food items were identified from the civet diet (Fig. 17). Among these, 13 food items were fruits, nine were leaves and shoots of plants, four were roots of plants, three were mammals, three were birds and four food items were from invertebrates. Thirty four percent of the diet was composed from fruits, mainly *P. americana* (11.5%), *Musa* sp. (3.9%), *C. africana* (3.6%), palm (2.5%), *Ficus* spp. (2.3%) and *P. guajava* (2%). Fruits of five indigenous plants and eight species of commercial fruits were identified from this area. *Persea americana* fruit was observed in 77.1% of the collected scats. Among fruits, *P. americana* was the only major diet in this habitat. There was significant variation in the selection of *P. americana* over other fruits by civets in this habitat ($F = 8.20$, $df = 12$, $p < 0.05$). Multiple comparison using LSD test showed the variation was due to the preference of *P. americana* to all other fruits (LSD, $\alpha = 0.00$).

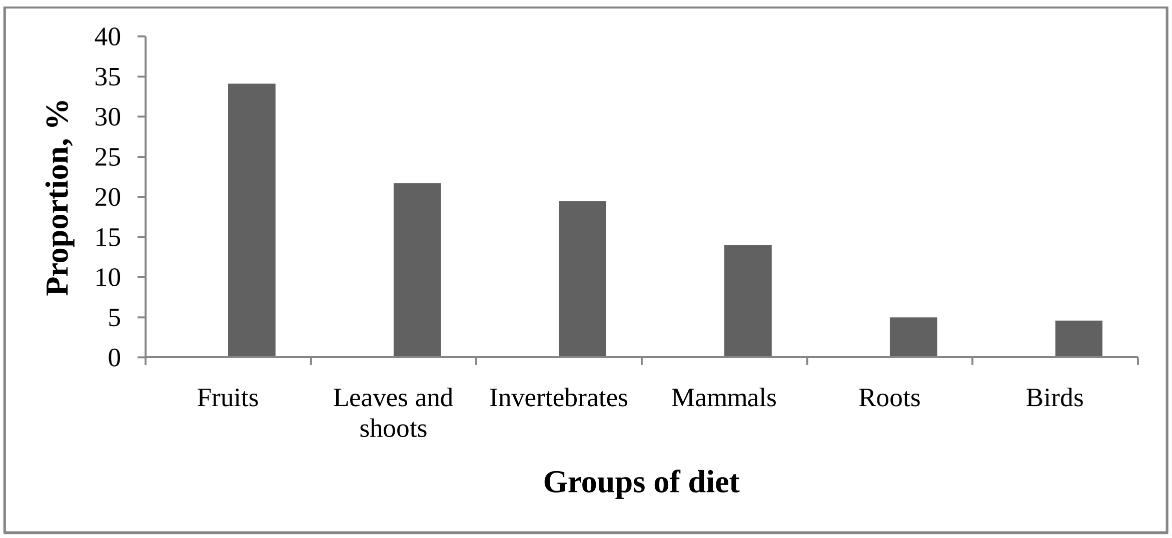

Figure 17. Proportion of each group of food items in the diet of civets in the farmland habitat

Leaves and shoots of grasses, *Saccharum* spp., vegetables, eucalyptus, *E. vetrcosum*, shrubs, herbs, *C. arabica* and *Catha edulis* constituted 21.7% of the civets' diet in this habitat. Grasses were identified from 83.2% of the scats and constituted the major portion of the civets diet. Leaf of *Saccharum* spp. was observed in 30.9% of scats collected from this habitat. Eucalyptus (0.3%), shrubs (0.2%), *Catha edulis* (0.1%) and *C. arabica* (only observed from 3 scats) contributed very few proportions in the diet of civets. Roots of plants such as *S. tubrosum* (0.9%), *I. batatas* (0.9%), *C. esculenta* (0.8%) and *D. carota* (0.2) constituted less than 3% of the civet diet in this area.

Animals constituted over 38% of the diet of civets. Among them, insects and rodents were identified from 94.6% and 54.2% of the scats, respectively, and constituted the major portion of the civet diet. Also snail, bone and meat, hair and eggs were included in the diet of civets in a good proportion. The contribution of worms (0.3%) and chicken (0.2) in the diet was insignificant.

Comparison between groups of food items varied significantly ($F = 67.47$, $df = 5$, $p < 0.05$. Post-hoc test using LSD showed that fruits were more preferred diet of civet than leaves and shoots ($p = 0.001$), roots and tubers ($p = 0.000$), mammals ($p = 0.000$), birds ($p = 0.000$) and invertebrates ($p = 0.000$). Civets fed more on leaves and shoots of plants than roots and tubers ($p = 0.000$), mammals ($p = 0.006$) and birds ($p = 0.000$), but not invertebrates ($p = 0.299$). Among animals, invertebrates were more preferred by civets than mammals ($p = 0.025$) and birds ($p = 0.000$). The contribution of mammals in the civet diet was higher than birds ($p = 0.003$).

Seasonal variation was not observed in the variety and proportions of diets of civets in farmland habitat ($t = 0.550$, $df = 72$, $p = 0.584$). There were 37 and 35 food items during the wet and dry seasons, respectively (Fig. 18). Only leaf of coffee and the fruit of *D. steudneri* were not included in the diet during the dry season. However, variation was observed in the composition of some food items between seasons. Diet composition of 12 food items (*P. americana*, palm, *C.*

africana, *Ficus* spp., *Saccharum* spp, vegetables, shrubs, *S. tuberosum*, *I. batatas*, rodents, hair and millipedes) showed an increase in proportion during the dry season compared to during the wet season. The composition of 14 (37.8% of the overall) food items was not changed during both seasons. But, 11 food items showed a decrease in their relative occurrence during the wet season than the dry season.

Some of the food items contributed only little portion of civets' diet during the wet and dry seasons. For example, fruits such as *M. indica* (0.9%), *D. caffra* (0.4%) and pumpkin (0.1%), leaves and shoots of herbs (0.5%), eucalypts (0.3), shrubs (0.2%) and *Catha edulis* (0.1%), roots of *C. esculenta* (0.8%) and *D. carota* (0.2%) and worms (0.3%) constituted less than 1% of the civet diet. Part of a chicken identified in 4 and 7 fecal samples during wet and dry seasons, respectively, also contributed very small portion of the diet.

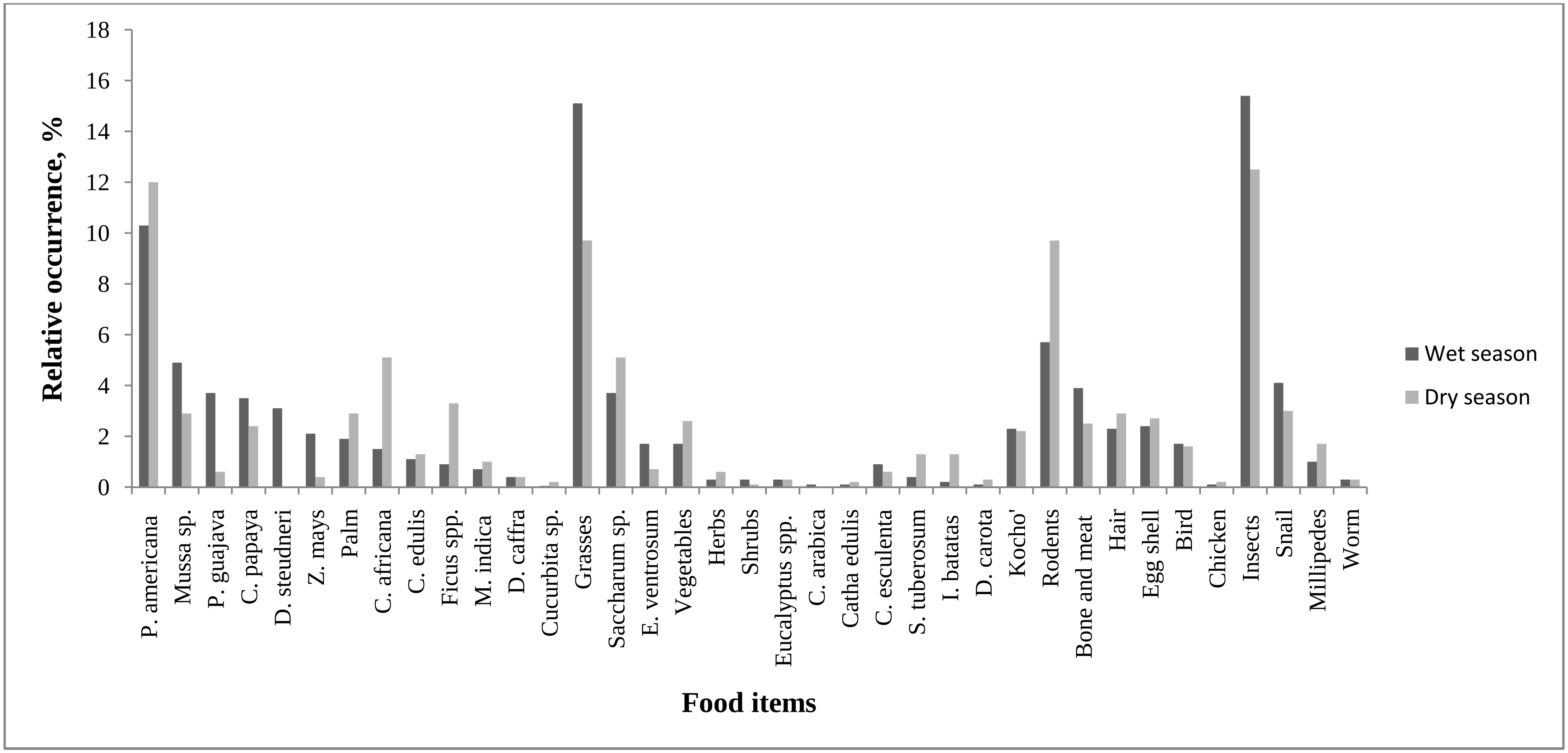

Figure 18. Food items identified from civets diet during the wet and dry seasons in the farmland habitat

During the wet season, 34% of the diets were fruits, mainly *P. americana*, *Musa* sp., *P. guajava*, *C. papaya* and *D. steudneri* in the farmland area. But, the proportion of fruits in the diet was reduced to 32.5% during the dry season. Among fruits, *P. americana* (10.3% wet and 12% dry) was the only major food item of civets' diet during both seasons in this habitat. Leaves and shoots of plants constituted 23.3% and 19.3% of the diet during wet and dry seasons, respectively. Grass was the major diet of civets among this group during the wet season, while both grass and sugarcane were the major diets during the dry season. Roots of plants were included only in 1.6% and 3.5% of the diet during the wet and dry seasons, respectively.

Food items of animal sources were included in 36.9% and 37.1% of the diet of civets during the wet and dry seasons, respectively, in the farmland habitat. Among animals, insects (frequency 91.3% in the scats) were the major diet of civets during the wet season. During the dry season, insects (frequency 98.7% of the scats) and rodents (occurrence 76.2% of the scats) were among the major diet of civets from animal groups.

In the natural forest, 29 food items were identified from 723 scats collected from the area (Fig. 19). Fruits with 11 species of plants were the most common diet of civets, followed by leaf and shoots (seven species) and invertebrates (four items). Mammals and birds were also included in the diet. Only *C. esculenta* was observed from root plants in this habitat. Part of a chicken was identified from four scats in this habitat. *Podocarpus falcatus* and *S. nigra* fruits were identified in the civet feces only from this habitat, but with the occurrence of less than 1%.

Fruits of various species of plants were the most preferred diet of civets with occurrence in more than 37% of the diet. Figs (11.8%), *C. africana* (9.6%), *P. americana* (6.3%) and *D. steudneri* (3.8%) were among the common fruits consumed by civets in the natural forest area. Other fruits such as date palm, *P. guajava* and *Cucurbita* sp. constituted only small portion of civet diet. Fruits of *Ficus* spp. and *C. africana* were observed in 51.5% and 41.8% of the scats collected from natural forest habitat, respectively. They were among the major diets of civet.

Leaves and shoots of grasses (10.2%), eucalypts (1.4%) and sugarcane (0.8%) constituted over 12% of the diet of civets. Among the leaves and shoots, shrubs, herbs, vegetables and *E. ventrosum* were included in the diet of civets, but in small proportion. Over 44% of the collected scats contained grasses, as a major component of civet diet. Vegetables with leaves and seeds of tomato were identified from scats in this habitat. Food items of civets from plants constituted more than 52% of the overall diets in the natural forest habitats.

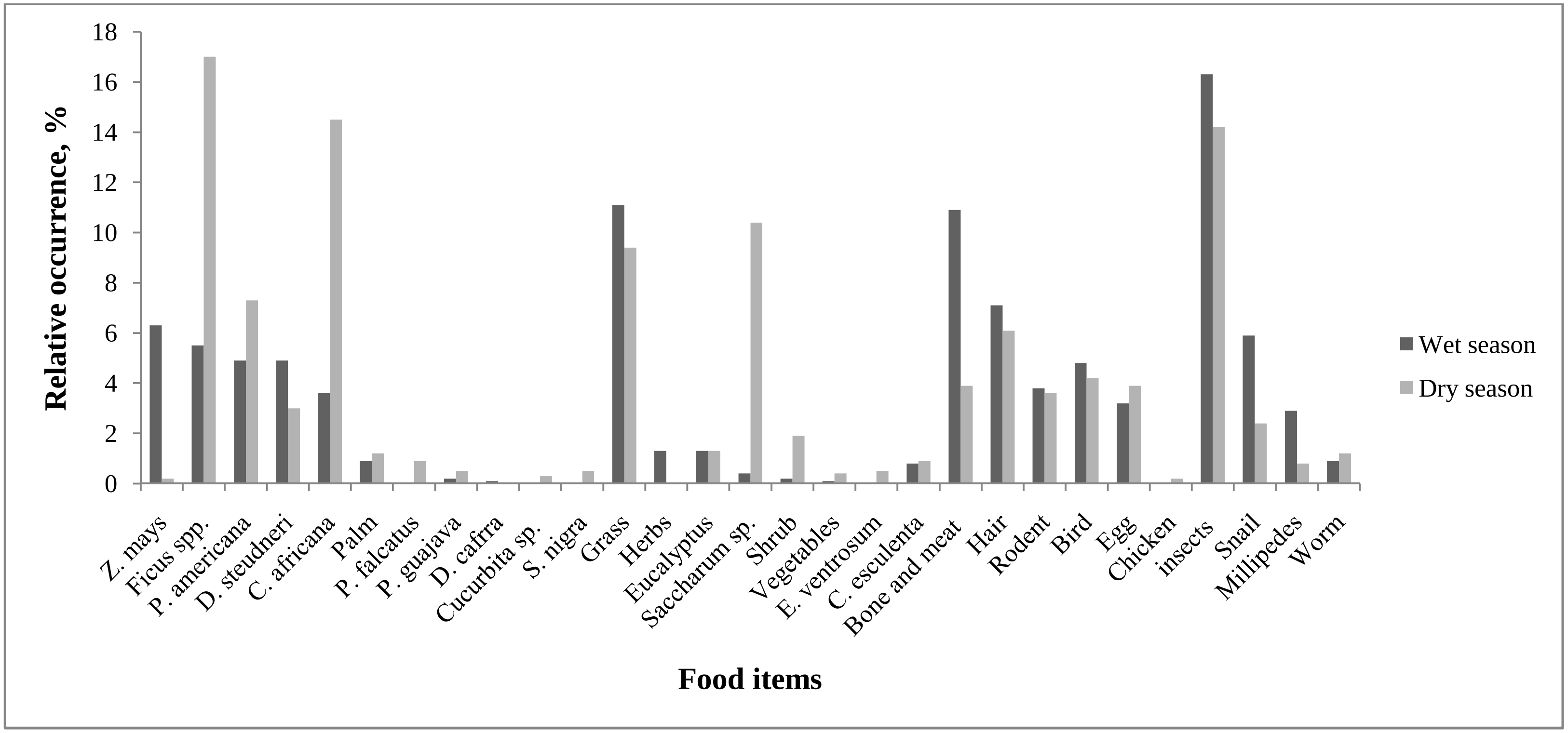

Figure 19. Proportion of each of the food items in the diet of civets during the wet and dry seasons in natural forest

The proportion of animals in the diet of civet was 47.3% of the total diet in natural forest area. Among these, insects, bone and meat and hair contributed 28.7% of the diet. Birds, snail, rodents, egg and millipedes constituted 4.5%, 3.9%, 3.7%, 3.6% and 1.9% of civets' diets, respectively. Insects, bone and meat were the common diet of civets. Insects (identified from 66% of scats) were the major diet of civets among all animals identified from the scats of civets collected from this habitat.

The proportion of different category of diets varied (Fig. 20) and showed statistically significant difference between groups of diets ($F = 6.1$, $df = 5$, $p = 0.024$) with preference to fruits, leaves and shoots of plants and invertebrates. Post-hoc test using LSD showed that fruits were more preferred by civets to roots ($p = 0.002$), mammals ($p = 0.039$) and birds ($p = 0.007$) in the natural forest habitat. Leaves and shoots were more preferred to roots ($p = 0.038$).

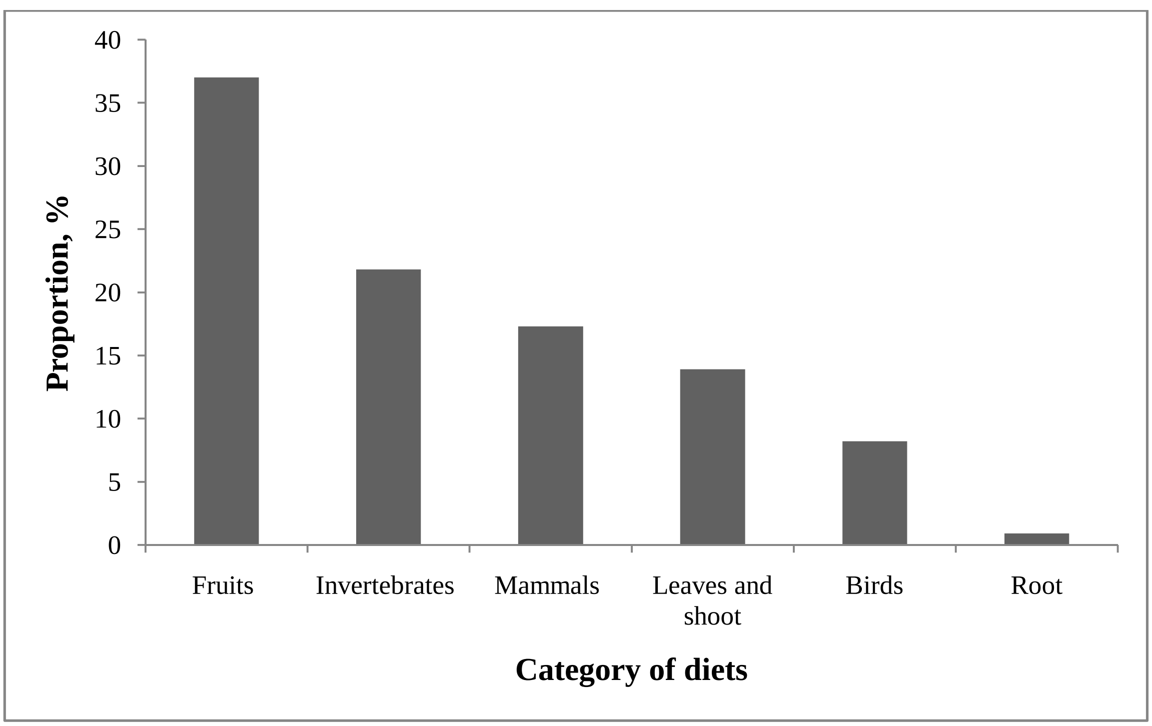

Figure 20. Proportion of each group of food items recorded in the diet of civets in the natural forest habitat

Seasonal variation was not observed in the variety of food items included in the diet of civets. Twenty seven food items were identified during the wet season, while 28 food items were observed during the dry season. *Cucurbita* sp. and *S. nigra* were not observed during the wet season, but were present during the dry season with small proportion (< 0.8 each). Only herbs were not included in the diet of civets during the dry season.

Statistically significant variation was observed in the proportion of civets diets in the natural forest habitat ($t = 2.885$, $df = 56$, $p < 0.05$). The occurrence of *Z. mays* ($\chi^2 = 77.69$, $df = 1$, $p < 0.05$), snail ($\chi^2 = 13.45$, $df = 1$, $p < 0.05$), bone and meat ($\chi^2 = 32.4$, $df = 1$, $p < 0.05$) and millipedes ($\chi^2 = 14.52$, $df = 1$, $p < 0.05$) showed statistically significant variation between seasons, with high occurrence of these items during the wet season. The occurrence of fruits of *Ficus* spp. ($\chi^2 = 125.42$, $df = 1$, $p < 0.05$), *P. americana* ($\chi^2 = 17.16$, $df = 1$, $p = 0.05$), *P. falcatus* ($\chi^2 = 6.37$, $df = 1$, $p < 0.05$), *Saccharum* spp. ($\chi^2 = 6.0$, $df = 1$, $p < 0.05$), egg ($\chi^2 = 5.05$, $df = 1$, $p < 0.05$) and rodents ($\chi^2 = 26.73$, $df = 1$, $p < 0.05$) was more in the diet of civets during the dry season.

Twenty six food items were identified in the scats collected from urban area. Eight species of fruits (five commercial fruits and three fruits of indigenous trees), leaves and shoots of four plants and roots of three plants were consumed by civets. Among animals, remains of mammals, birds, fish, insects, snail, worms and millipedes were observed. Fruits (28.7%) were the more consumed food items than other items in this habitat (Fig. 21). Fruits of *Ficus* spp. contributed for high proportion (14.3%) of fruits in the diet of civets. Fish was among the major diet of civets in this habitat. It was observed in 92.3% of the collected scats and only identified from the feces of civets in this habitat. Leaves and shoots of plants composed over 16% of the diet. Parts of different vegetables were commonly observed (9.4%) in the diet of civets in urban area. Overall, fish (23.3%), fruits of *Ficus* spp. (14.3%), vegetables (9.4%), egg (6.4%), insects (6.4%) and grass (5.6%) were the common food items of civets in the urban habitat.

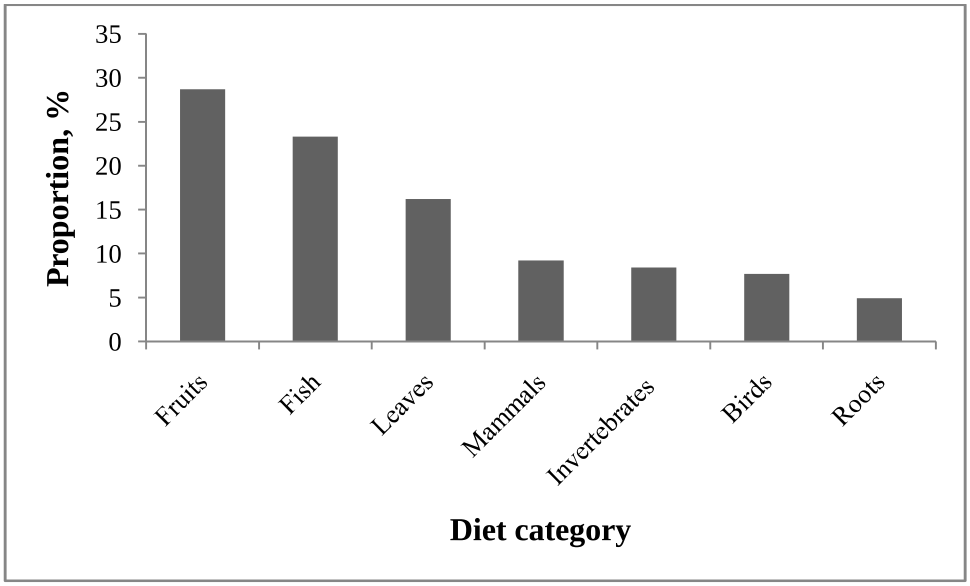

Figure 21. Category of food items recorded in the diet of civets in urban habitat (proportion indicates the relative occurrence of each diet category in the diet)

Diet selection by civets varied significantly between groups (F = 3.9, df = 6, p = 0.048). Post hoc tests using LSD revealed that the composition of fruits and fish (p = 0.08) and fruits and leaves (p = 0.071) did not vary significantly among the food items of the civet in the urban area. But, fruits were more preferred than roots (p = 0.005), mammals (p = 0.013), birds (p = 0.008) and invertebrates (p = 0.011) by civets in the urban area.

Seasonally, there was no variation in the variety of food items and composition of each food in the diet of civets (t = 0.610, df = 50, p = 0.545). During both seasons, 26 food items were recorded in the diet (Fig. 22). However, the importance of some food items varied between seasons. For instance, the fruit of *C. edulis* was not a common diet of civet during the wet season (1.9% relative occurrence), but it became a common diet during the dry season (5.9%).

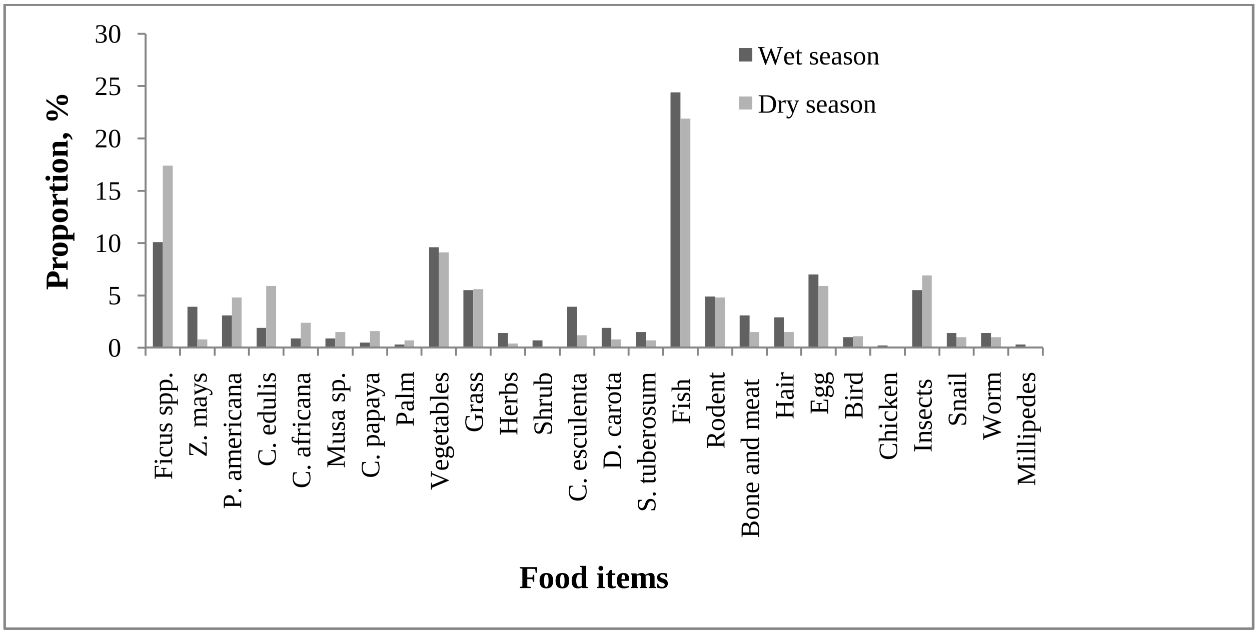

Figure 22. Food items identified in the scats of civets in urban areas during wet and dry seasons

In the present study area, African civets fed on 15 types of fruits. Among these fruits, seeds of *P. americana* and *M. indica* were bigger and not swallowed by civets. Fruits of *Musa* sp. were included in the diet, but there were no seeds or other part of *Musa* sp. that can normally germinate. The seeds of all other fruits eaten by civets were identified from scats. The seeds of eucalypts and tomato were identified from the scats of civets, though the fruits of these plants were not identified from the diet of civets.

Civets consumed the fruits with seeds in the case of *C. edulis*, *C. africana*, *Ficus* spp., palm, *D. steudneri*, *P. guajava*, *P. falcatus*, *S. nigra* and *D. caffra*. Among these, the seed of casmir was larger in size (> 3 cm) than the other seeds consumed by civets. Part of *Cucurbita* sp. and *C.*

papaya was eaten with the seeds. Three (e.g. *C. edulis*) to 150 seeds (e.g. *Ficus* spp.) of plants were observed during each defecation after eating these fruits with seeds. They accumulate the seeds in their civetry (Fig. 23). The level of seed damage after gastrointestinal passage was insignificant. Over 97% of seeds were not damaged after passing through the gastrointestinal track.

Figure 23. Seeds and fruits of *P. guajava* seen in one of the civetries

Seedlings of trees, herbs, commercial fruits and tubers germinated on civetries located within the four study habitats (Table 6). Thirteen species of plants that germinated were identified from civetries. *Cordia africana* (55.8%) was the most commonly germinated plant in all habitats where civetries were located. Only *C. africana* and *Z. mays* seeds were germinated on civetries that located in all the four habitats. Most of the germinated plants (nine species) were observed on civetries located in farmland. Seedlings of *C. esculenta*, *Cucurbita* sp., *C. edulis*, *Z. mays* and tomato were observed germinating on civetries located in the natural forest. *Cordia africana*, date palm *D. steudneri* and *Ficus* spp. germinated on civetries located in agricultural lands in addition to their natural habitats.

Table 6. Various seeds of plants that germinated on civetries across the four study areas (+ indicates the presence of germinated plant in that specific habitat, zero (0) indicates the absence of germinated plant, n stands for the number of civetry with germinated seeds)

Seedling	n	Civetries with seedlings in different habitats			
		Commercial farm	Farmland	Natural forest	Urban area
C. africana	24	+	+	+	+
Z. mays	9	+	+	+	+
Grasses	8	+	+	+	0
D. steudneri	7	0	+	0	0
Palm	7	0	+	0	0
Ficus spp.	6	0	+	+	+
Cucurbita sp.	3	0	+	+	0
C. esculenta	3	0	+	+	+
C. edulis	2	0	0	+	0
Eucalyptus sp.	2	0	0	+	0
P. guajava	2	0	+	0	0
S. nigra	1	0	0	+	0
Tomato	1	0	0	+	0

Bulk density of soil samples taken from civetries ranged from 0.68 to 0.96 g/cm^3 (mean of 0.78 g/cm^3), while the bulk densities of non-civetry soils taken from the same localities ranged from 0.632 to 1.067 g/cm^3 (mean 0.88 g/cm^3). In 93% of the civetry soils, the bulk density was less than non-civetry soils, but not statistically significant. Bulk densities of civetry soils reduced 2−57% from the bulk densities of respective non-civetry soils. Only a soil sample taken from *Catha edulis* farm (sample location 14) showed higher bulk density for civetry than non-civetry soil (Fig. 24).

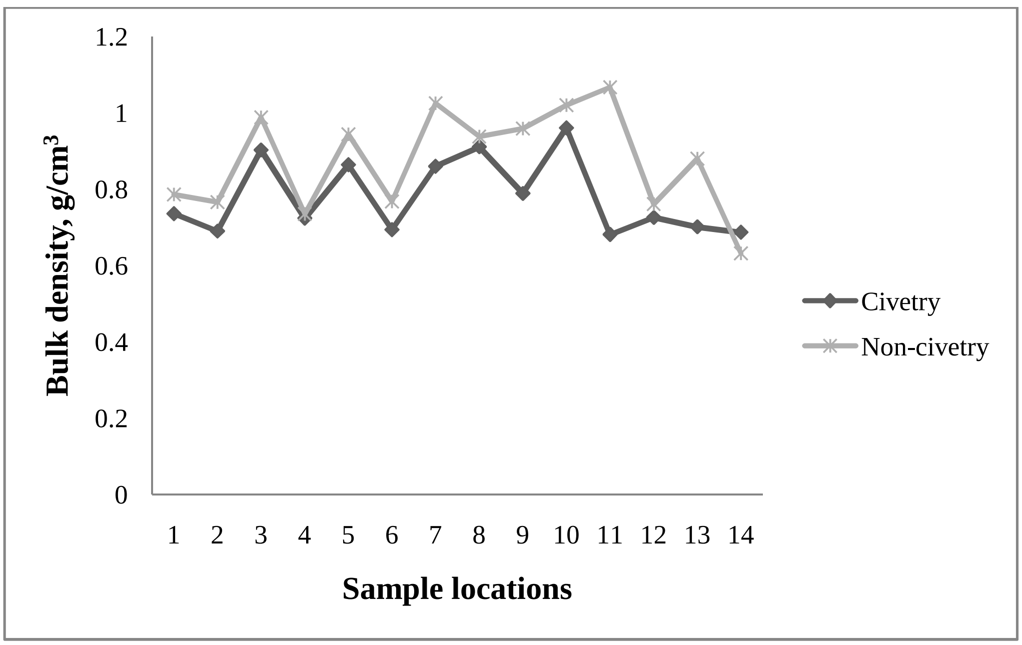

Figure 24. Bulk density of sample soils taken from civetry and non-civetry locations

Soil samples from civetry locations were observed to hold higher moisture than non-civetry soils. Mean moisture content was 19.23% and 14.88% for civetry and non-civetry soils, respectively. In civetry soils, moisture content ranged from 8.4% to 41%. Seventy seven percent of the samples collected from civetry showed an increase of moisture content (1−100 %) from respective samples collected from non-civetry soils. Soils from sample locations 5, 9 and 13 showed high moisture content in non-civetry soil than from civetry soils (Fig. 25).

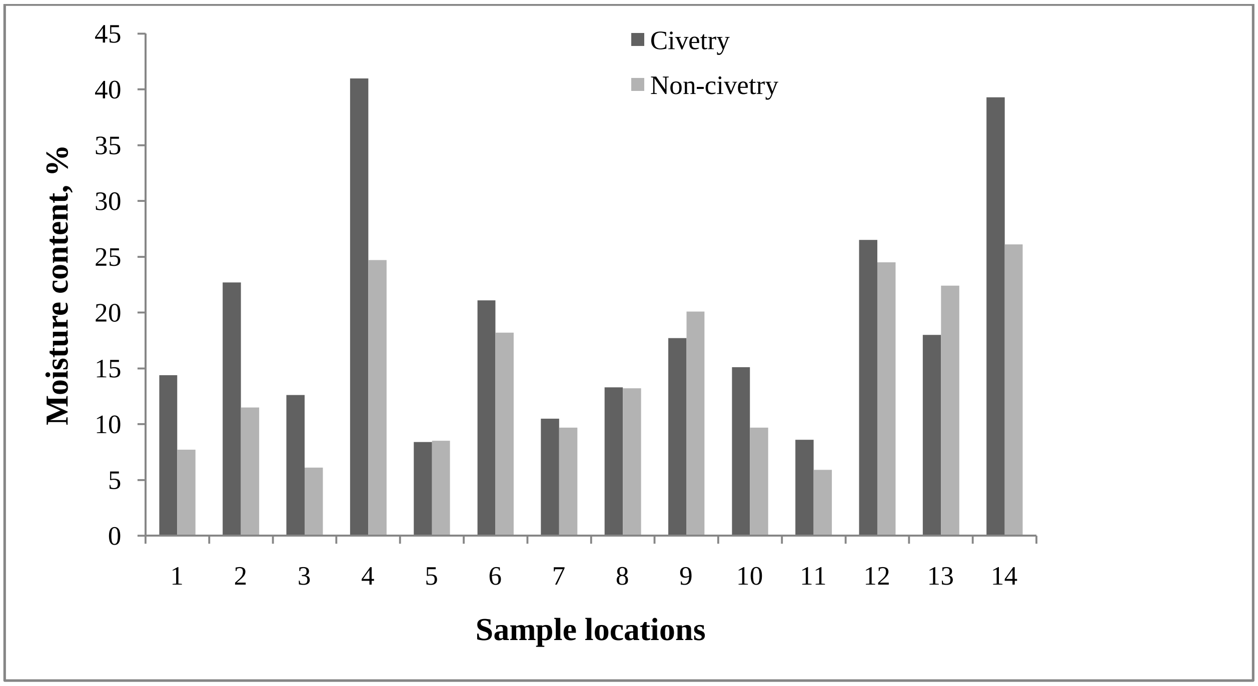

Figure 25. Moisture content of soil samples taken from civetry and non-civetry locations

Organic carbon content of soil significantly varied between civetry and non-civetry sites ($t = 2.14$, $df = 26$, $p < 0.05$). Civetry soils contained higher organic carbon content than non-civetry soils. On an average, organic carbon content of 5.1% and 4.1% were recorded in civetry and non-civetry soils, respectively. Civetry soils contained organic carbon of 3.1−9.2%, while the organic carbon content in non-civetry soils was from 2.8 to 5.5%. In 85.7% of soil samples, civetry soils showed increased organic carbon content at the range of 1.7−85.5% compared with non-civetry soils. Civetry soils collected from sample locations 4 and 11 contained lower organic carbon content compared to non-civetry soils collected from the nearby locations (Fig. 26).

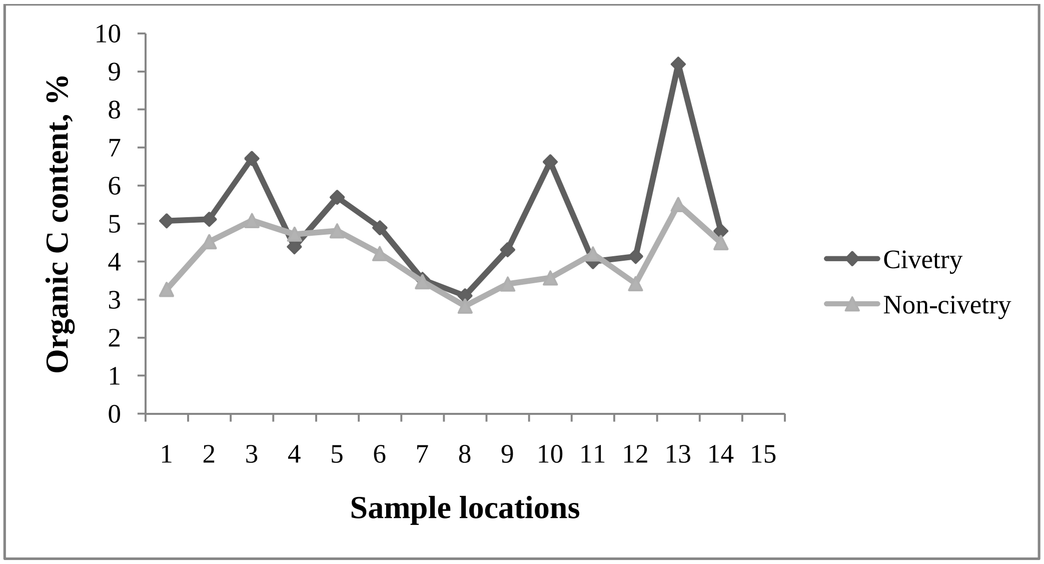

Figure 26. Organic carbon content in the civetry and non-civetry soils

Organic matter content of soils significantly varied between civetry and non-civetry sites ($t = 2.512$, $df = 26$, $p = 0.041$). Civetry soils contained high organic matter that ranged between 5.34−15.84% compared with non-civetry soils which contained organic matter content in the range of 4.88−9.48%. Mean organic matter content was 8.81±0.72% and 7.10±0.37% in civetry and non-civetry soils, respectively. In all sample locations, except locations 4 and 11, the amount of organic matter content in civetry soils were higher than in non-civetry soils (Fig. 27).

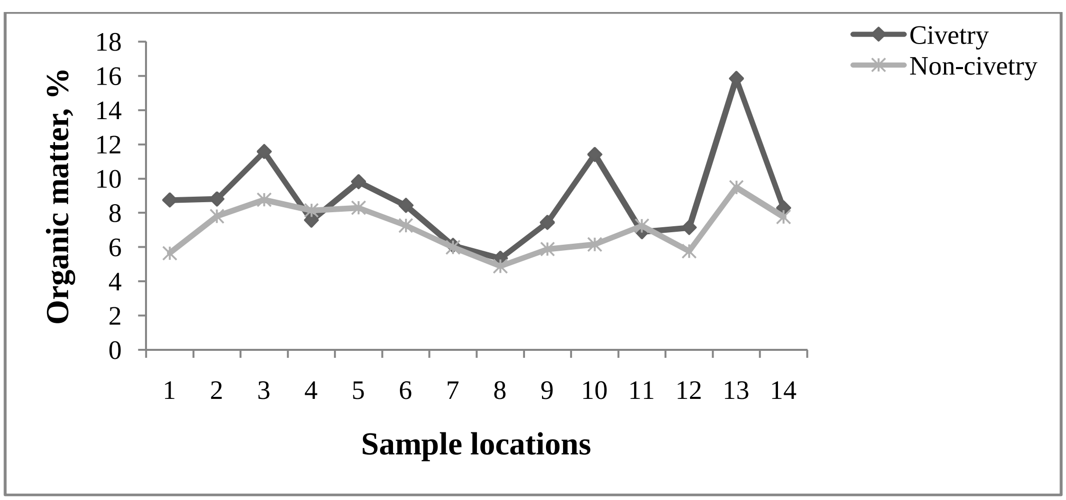

Figure 27. Organic matter content between civetry and non-civetry soils

The pH of civetry soils ranged between 5.99−7.71. The civetry soil was slightly acidic to slightly alkaline. Over 74% of civetry soils had alkaline properties. In non-civetry soils, the pH value ranged between 5.9−7.14. Only 35.7% of soils had alkaline properties in non-civetry samples, whereas 65% of the non-civetry soil had acidic properties (Fig. 28).

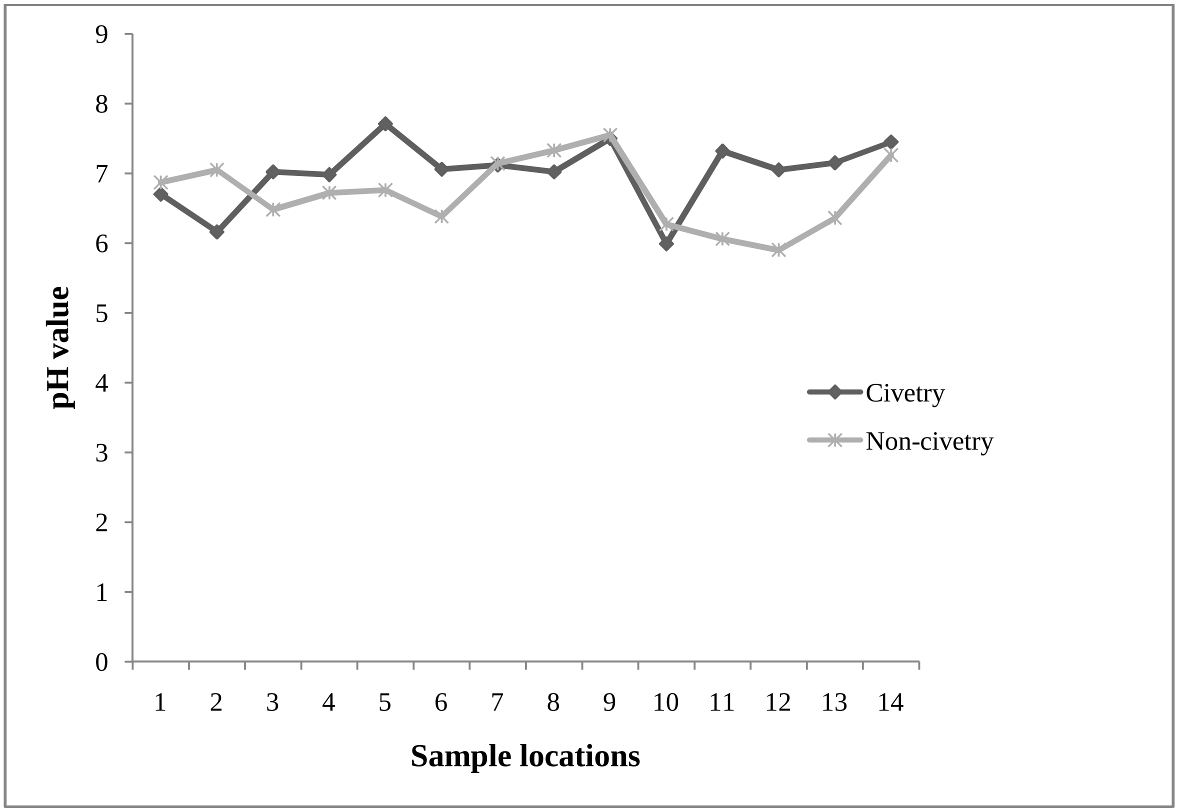

Figure 28. pH of samples of soils from civetry and non-civetry sites

3.4. Scent marking

A total of 351 scent marked sign-posts were identified. Among these, 163, 144 and 44 environmental sign-posts were recorded from natural forest, urban and farmland areas, respectively. Density varied from 21.5−52.5 sign-posts per ha around civetry sites, while it was 13−50.5 sign-posts per ha in non-civetry areas (Table 7). Mean density of scent marked sign-posts was 35.8 per ha in the area around civetries. There was a significant variation in the density of scent marked sign-posts between civetries (χ^2 = 14.49, df = 2, p < 0.05). Density of scent marked sign-posts was 34.4 per ha of area in non-civetry areas. Variation between the densities of scent marked sign-posts between non-civetry areas was also statistically significant (χ^2 = 12.66, df = 2, p < 0.05).

Table 7. Number of scent marked sign-posts across the study area (*Values were from two different civetries in the specified area, [a] values were from two different transect line counts in the specified area)

Location	Number of sign-posts			
	Farmland	Natural forest	Urban area	Total
Civetry	31	105*	43*	179
Non-civetry	13	58[a]	101[a]	172
Total	44	163	144	351

Distribution of scent marked objects was not uniform. Most of the scent marked objects were densely accumulated surrounding the civetries in natural forest and farmland areas, while the sign-posts were more in non-civetry area in the urban area.

Forty four scent marked objects were identified from sample civetry and non-civetry areas in farmland habitat. Density of scent marked objects was 31 and 13 per ha of area around the civetry and non-civetry area, respectively. Scent marked objects were densely distributed surrounding the civetry, while the sign-posts were dispersed in non-civetry areas (Fig. 29).

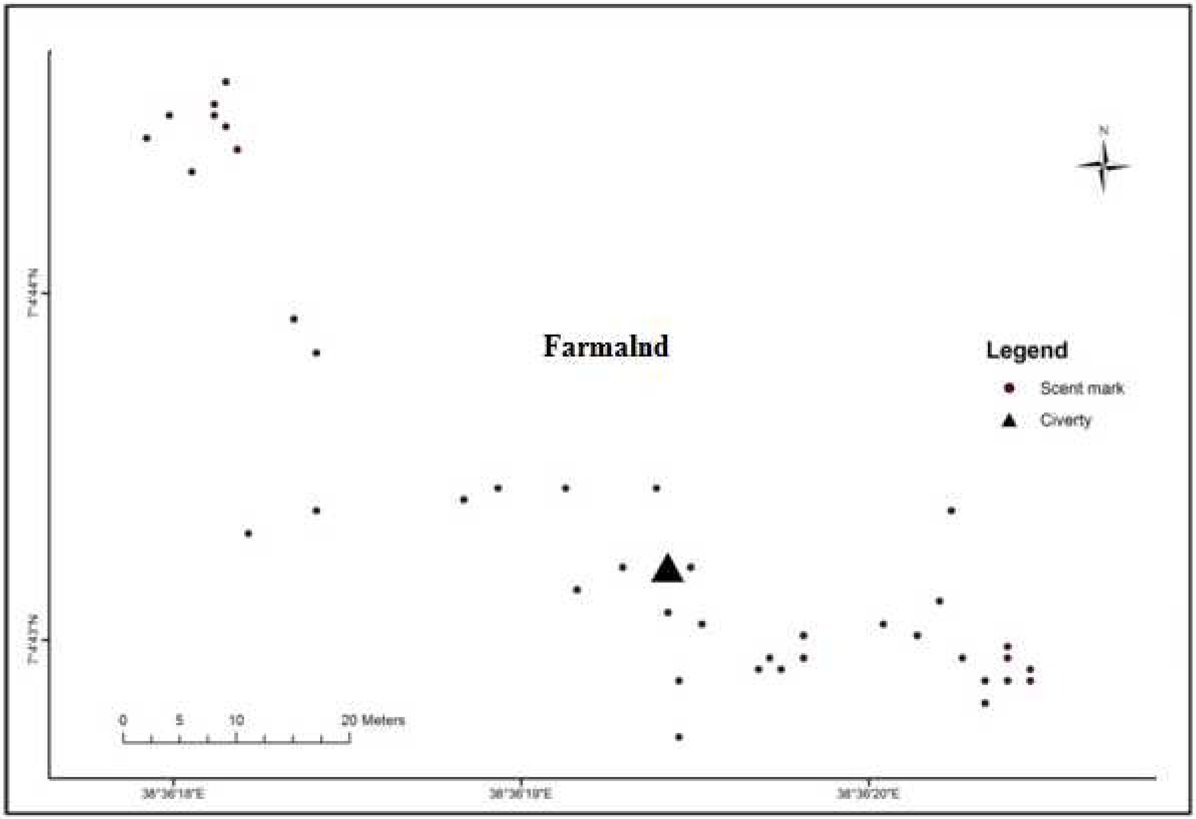

Figure 29. Distribution of scent marked objects around civetry in farmland area

More number of scent marked objects were recorded from civetry area than non-civetry area ($\chi^2 = 7.36$, df = 1, $p < 0.05$). More than 70% of the scent marked objects were distributed within 50 m of the civetries in the farmland habitat.

Civets used stem, leaf and twigs of *Eucalyptus* sp, *Grevillea* sp., *P. guajava*, *Saccharum* spp., *S. nigra* and fences as environmental sign-posts. *Eucalyptus* sp. (86.4 %) was more used as scent marking object than other objects in this area ($\chi^2 = 88.54$, df = 3, $p < 0.05$). Most of the scent marked objects were plants with rough surfaces (86.4%). More scent marking (93%) was located on stem in this habitat. The diameter of scent marked objects at the scent marked location ranged between 0.6−10 cm (mean = 2.6±0.35 cm).

On an average, 40% of the marked sign-posts faced towards pathway and 44.4% faced towards civetry (22.2%) and other side (22.2%) of the scent marked objects (Fig. 30). Most of the scent marked objects faced towards pathway than other directions ($\chi^2 = 27.13$, df = 5, $p < 0.05$). In few cases (4.4%), civets scent marked on all direction (circular) of the scent marked objects.

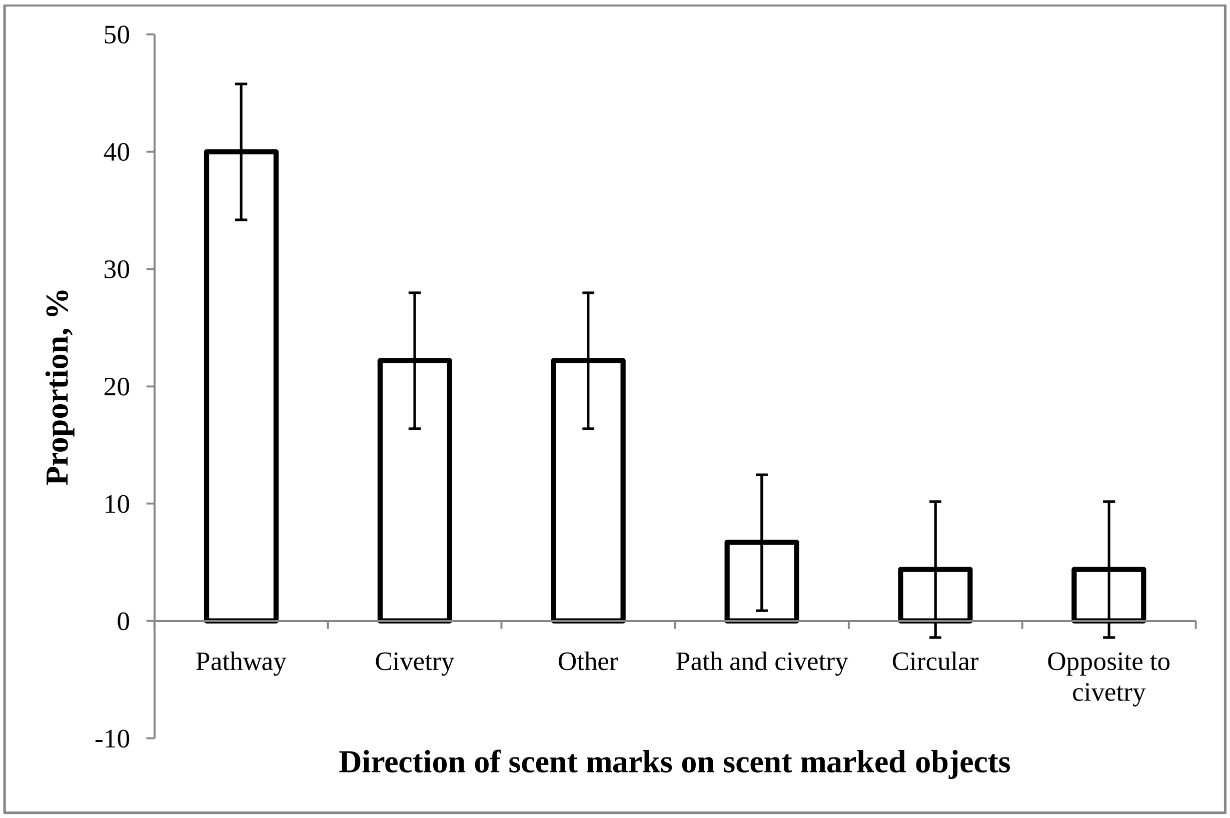

Figure 30. Direction of scent marks on environmental sign-posts of the African civets in farmland habitat

Distance of scent marked objects from nearby wildlife track ranged between 0−10 m (mean = 1.2±0.27 m). Most of the scent marked objects (88.64%) were distributed within 2 m distances from wildlife tracks. In few cases (5%), civets scent marked their perineal glandular secretion on objects located on pathways itself. The height of scent marked objects where the scent marks were laid ranged between 30−40 cm (mean = 33.25±0.23 cm), from the ground level. Over 72% of the perineal glandular secretion was marked at a height of 30−33 cm. Only 4.5% of the scent marked objects were observed to have a height of 40 cm, which were marked on top of other scent marks (Fig. 31).

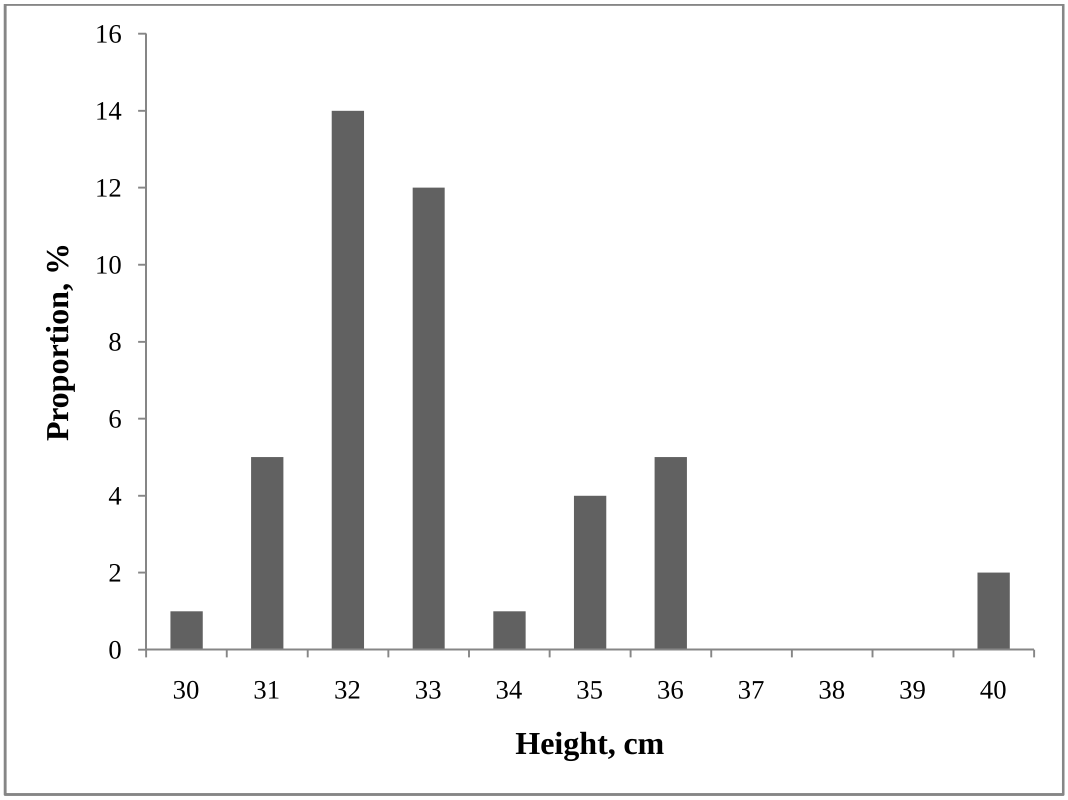

Figure 31. Height of scent marked objects from the ground where the scent marks were located

Color of perineal glandular secretions on scent marked objects was brown, white, dark and mixed (white and dark). Brownish colored secretion on scent marked objects (43.75%) were more common than other colors ($\chi^2 = 16.71$, df = 3, $p < 0.05$). Over 77% of the scent marks had brown and white colors (Fig. 32). Fresh scent marks were brown and white, while older marks were dark. In mixed colored scent marks, part of the scent mark was new (brown or white color) and the rest was older (dark color).

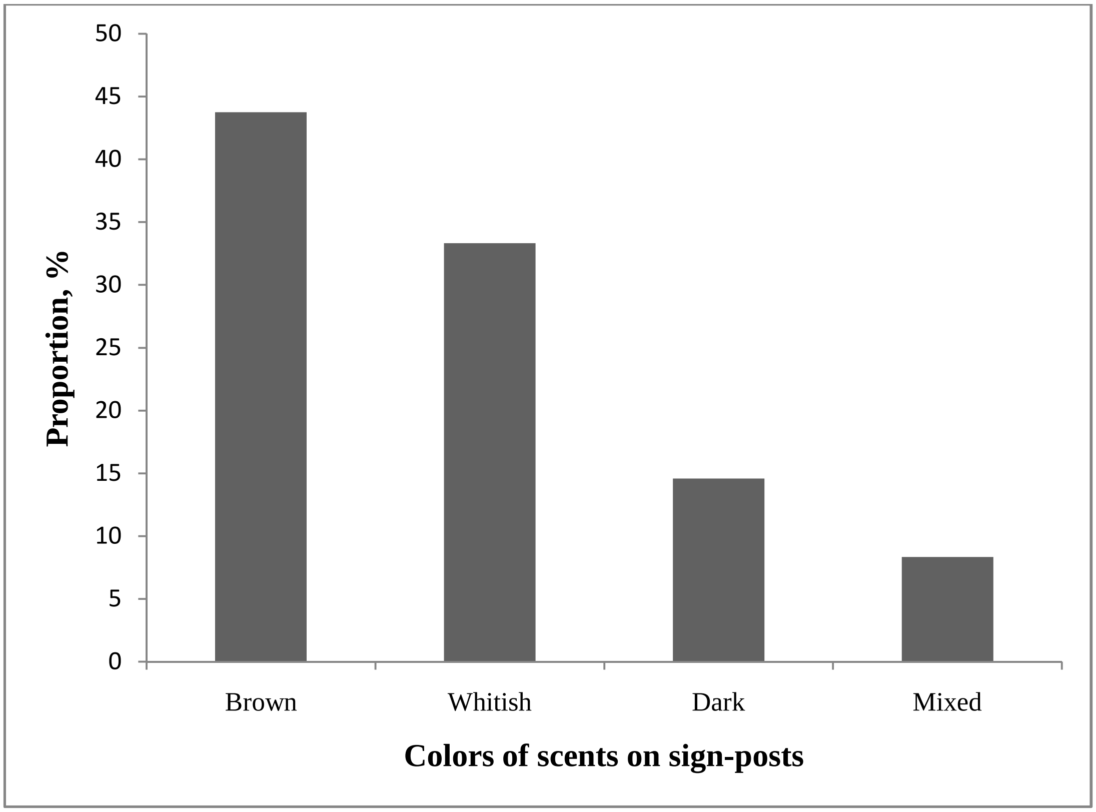

Figure 32. Proportion of color of the perineal glandular secretion on the environmental sign-posts in farmland habitat

Remarking after removal of scents from the scent-marked objects was observed on the same night of scent removal day on 9% of scent-marked objects. Almost 39% of the scent removed sign-posts were remarked within 5 days interval. In 53% of the scent-marked objects, remarking was observed within a week (Fig. 33). In 4.54% of the scent-marked objects, there was no remarking during the whole period of investigation. In some scent-marked objects, frequent remarking was observed.

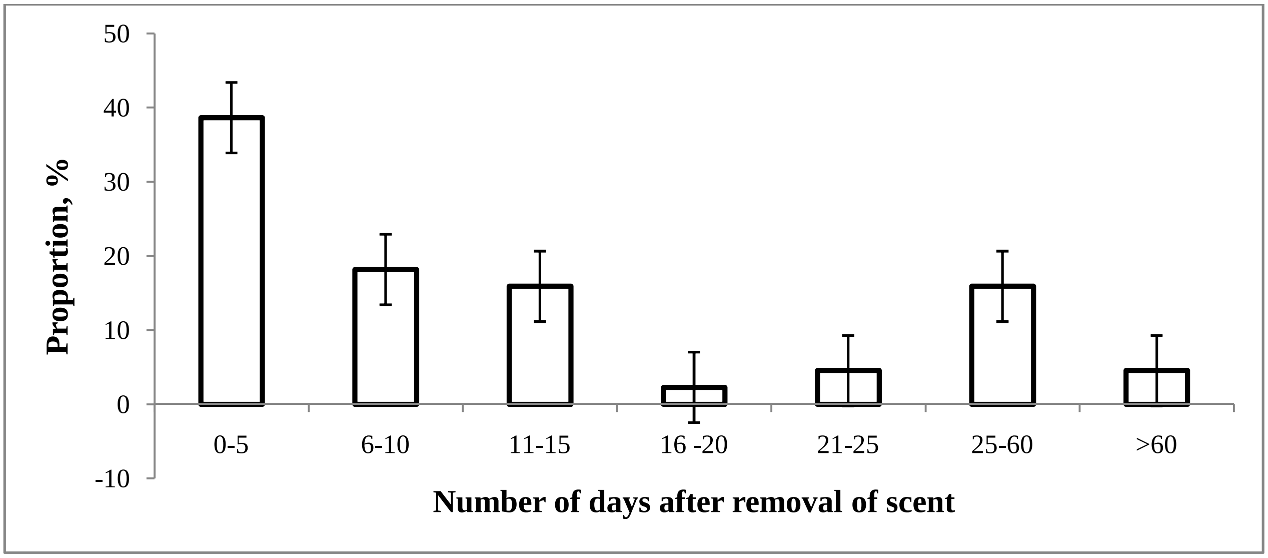

Figure 33. Scent remarking by the African civet after removal of the marked scent from the sign-posts (>60 days represents scent-marked objects that were not marked after removal of glandular secretion during the whole investigation period)

The amount of perineal glandular secretion available for collection from the marked sites varied during different times of remarking by civets. The mean weight of perineal glandular secretion was 0.091g per scent-marked objects during removal day. This amount was reduced in consecutive remarking and started to increase after fourth remarking (Fig. 34).

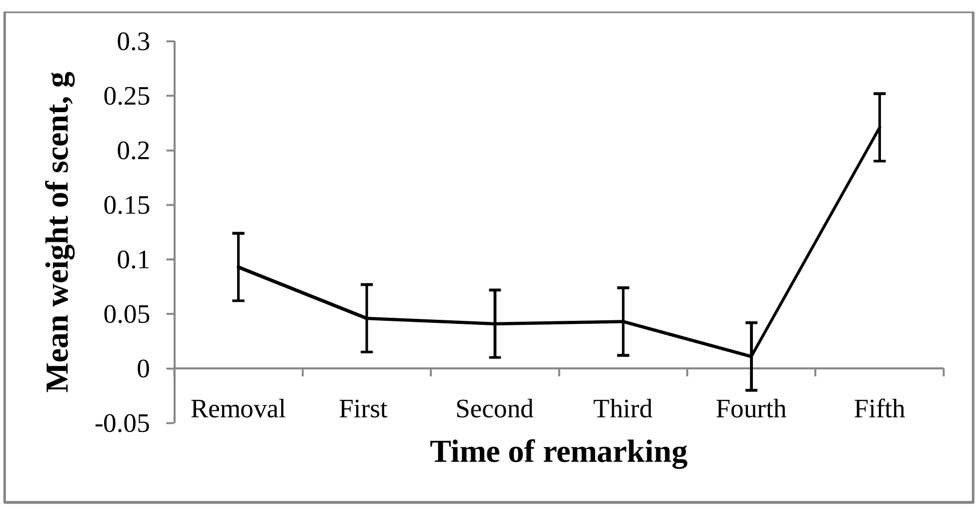

Figure 34. Mean weight of the collected perineal glandular secretion of civets during different sessions of remarking

In the natural forest habitat, 163 scent marked objects were identified around the civetry sites (n = 105 sign-posts) and non-civetry areas (n = 58 sign-posts). Mean density was 52.5 scent-marked objects per ha around civetries and 29 scent-marked objects per ha in non-civetry sites. Distribution of scent marked objects showed statistically significant variation between civetry and non-civetry sites ($t = 4.77$, $df = 2$, $p = 0.041$) (Fig. 35). Over 64% of the scent-marked objects were distributed around the civetries, while only 35% of the scent-marked objects were located in non-civetry sites.

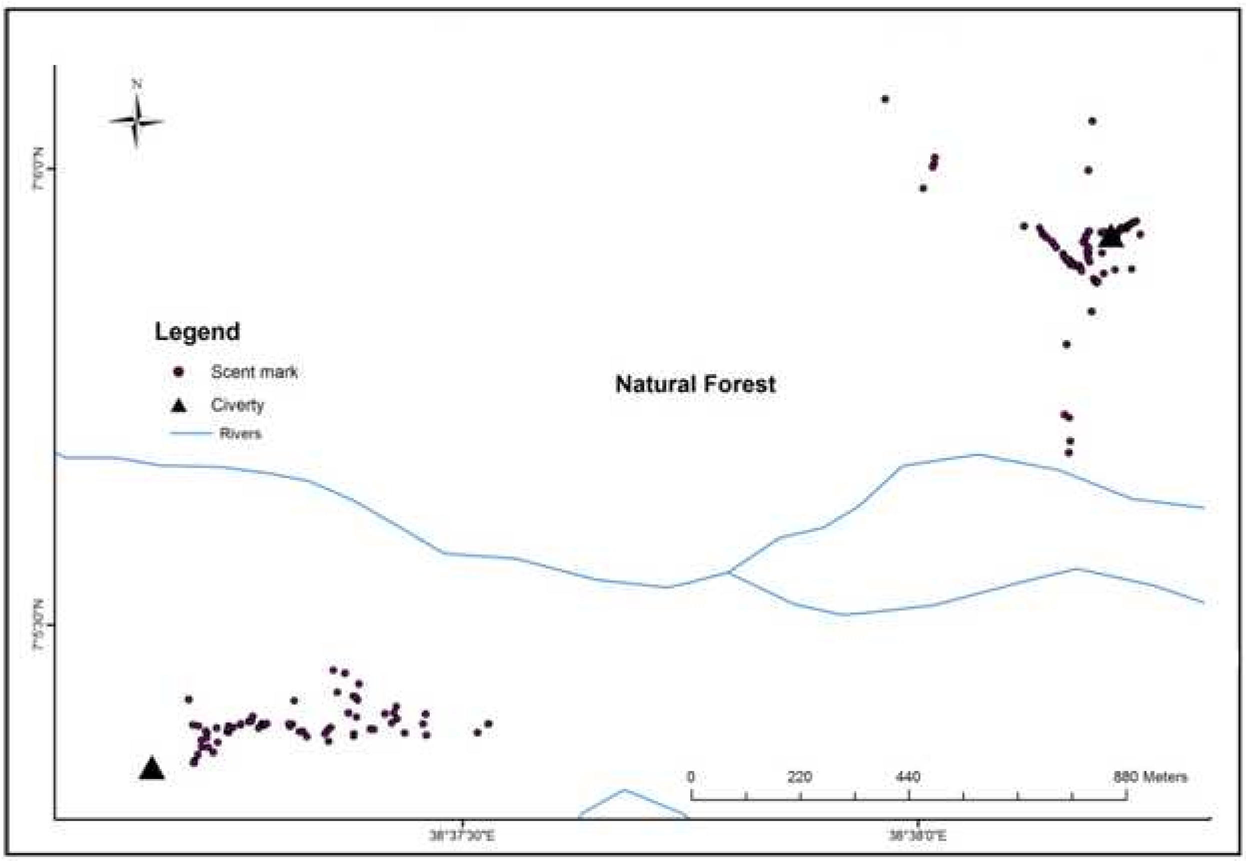

Figure 35. Distribution of scent marked objects around civetry and along pathways in natural forest habitat

Civets mostly used stem (92.4%) more than other parts of plants for scent-marking in this habitat. The diameter of scent-marked objects ranged between 0.1–38 cm with an average of 3.61 cm at the marked height. They used plant leaf only on few occasions (7.6%) for scent-marking. They preferred to scent-mark on smooth surfaces than on rough surfaces ($\chi^2 = 67.6$, df = 2, $p < 0.05$).

Overall, 72.4% of the scent-marks were directed towards the nearby pathway followed by other direction (8.6%) than towards civetry and pathway. Only 6.7% of the scent-marks were directed towards civetries, while 8% was directed opposite to the direction of civetry (Fig. 36). The variation between the directions of scent-marks was statistically significant ($F = 38.16$, df = 4, $p < 0.05$) with most of the scent-marks directed towards the nearby pathways. Multiple comparison tests (using LSD) showed that civets preferred to mark their scents directed to the nearby pathway than civetry ($p < 0.05$), opposite direction ($p < 0.05$), other direction ($p < 0.05$) and circular ($p < 0.05$) on the scent-marked objects.

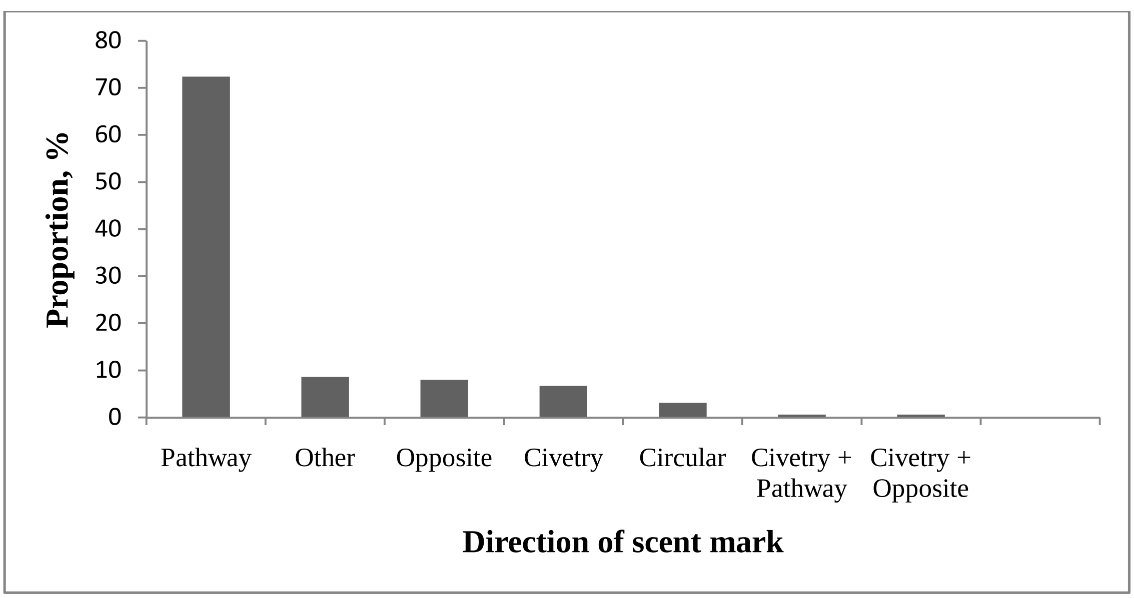

Figure 36. Direction of scent marks on sign-posts of the African civets in natural forest area

Civets marked their perineal glandular secretion along wildlife tracks at a distance ranging between 0−6 m (mean = 0.74±0.083 m). Eighty nine percent of the scent-marked objects of civets were identified within 2 m distances from nearest wildlife tracks in this habitat. Among these, nine percent of the scent-marked objects were located on the pathway. Mean height of scent-marked objects used by civets was 32.88±0.12 cm (range = 28–36 cm). Among the heights, height at 33 cm was more common (25%) than other heights in this habitat. Scent-marks at two different heights on the same signposts were also observed such as at heights 28 cm and 33 cm, 30 cm and 33 cm, 30 cm and 35 cm.

Fifty percent of the perineal glandular secretions on scent-marked objects were whitish, while the proportion of dark colored perineal glandular secretions was 25.2% in natural forest area. Only 3.1% of the scent-marked objects had mixed (dark with white or brown) colored secretions. In this habitat, sign-posts with whitish colored secretions were more common than other colors (χ^2= 72.36, df = 3, $p < 0.05$). Whitish and brownish colored secretion together accounted for 70.6% of all markings in this habitat.

The mean weight of perineal glandular secretion on each scent-marked object was 0.2±0.02 g (range 0.0001 – 1.28 g) in the natural forest habitat. Over 65% of the sign-posts had less than 0.2 g of secretions. Rarely (3.1%), environmental sign-posts had more than a gram of perineal glandular secretion. The amount of scents varied significantly between sign-posts in this habitat (t = 9.6, df = 162, $p < 0.05$). The amount varied during different sessions of remarking. On the removal day, a mean of 0.2 g was weighed, while it was reduced to a mean of 0.09 g during fourth session of remarking (Fig. 37).

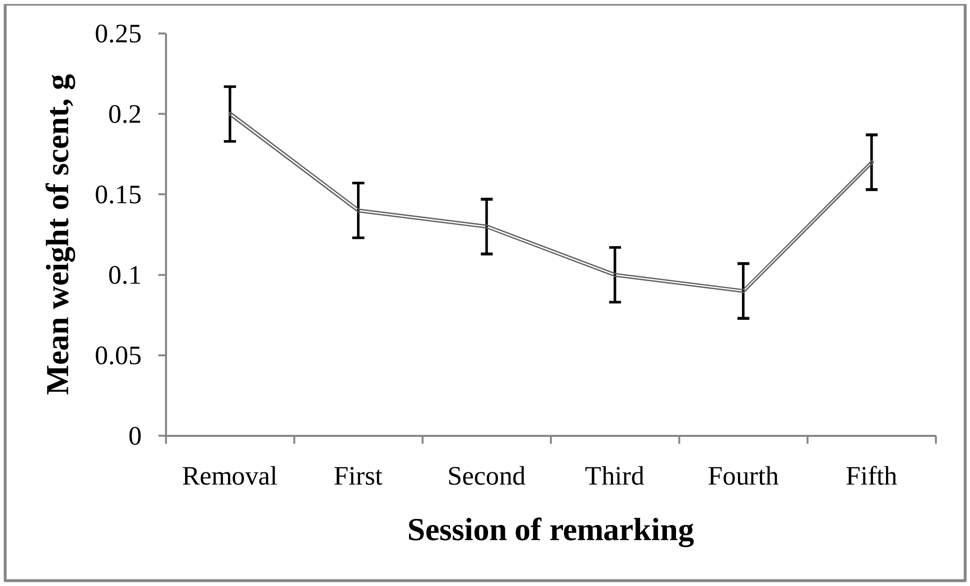

Figure 37. Mean weight of perineal glandular secretion of civets weighed at different session of remarking in natural forest area

Civets remarked 6.3% of the sign-posts on the same day of scent removal in natural forest area. They remarked 58% of their sign-posts within 8 days after removal of scents from the sign-posts. The frequency of remarking was reduced after 15 days of removal of scents from sign-posts. Only 2.8% of the marked sites were remarked between 16–20 days of removal and 4.4% were remarked between 21–25 days after removal. Over 5% of scent removed sign-posts remained without remarking by civets during the study period (Fig. 38).

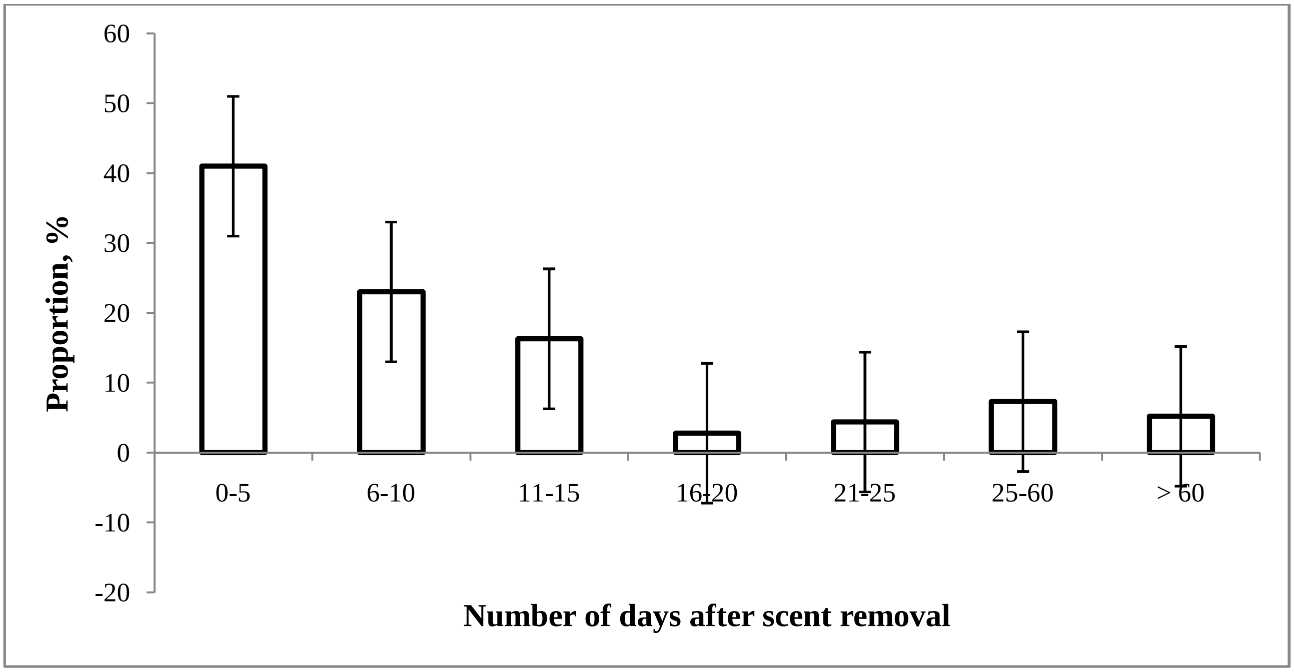

Figure 38. Scent remarking by the African civet after removal of the marked scents from scent-marked objects in natural forest area (>60 days represents scent-marked objects that were not marked after removal of glandular secretion during the whole investigation period)

During the current investigation, 144 sign-posts were identified from urban sample site. In this site, the density of scent-marked objects around civetries (21.5 sign-post per ha) was smaller than the density of scent-marked objects in non-civetry areas (50.5 sign-posts per ha). The variation on densities of sign-posts between civetry and non-civetry areas was statistically significant ($t = 7.62$, $df = 2$, $p < 0.05$).

Most of the sign-posts (70.1%) were identified from non-civetry locations. Scent marked sign-posts were distributed in a linear pattern in urban areas (Fig. 39).

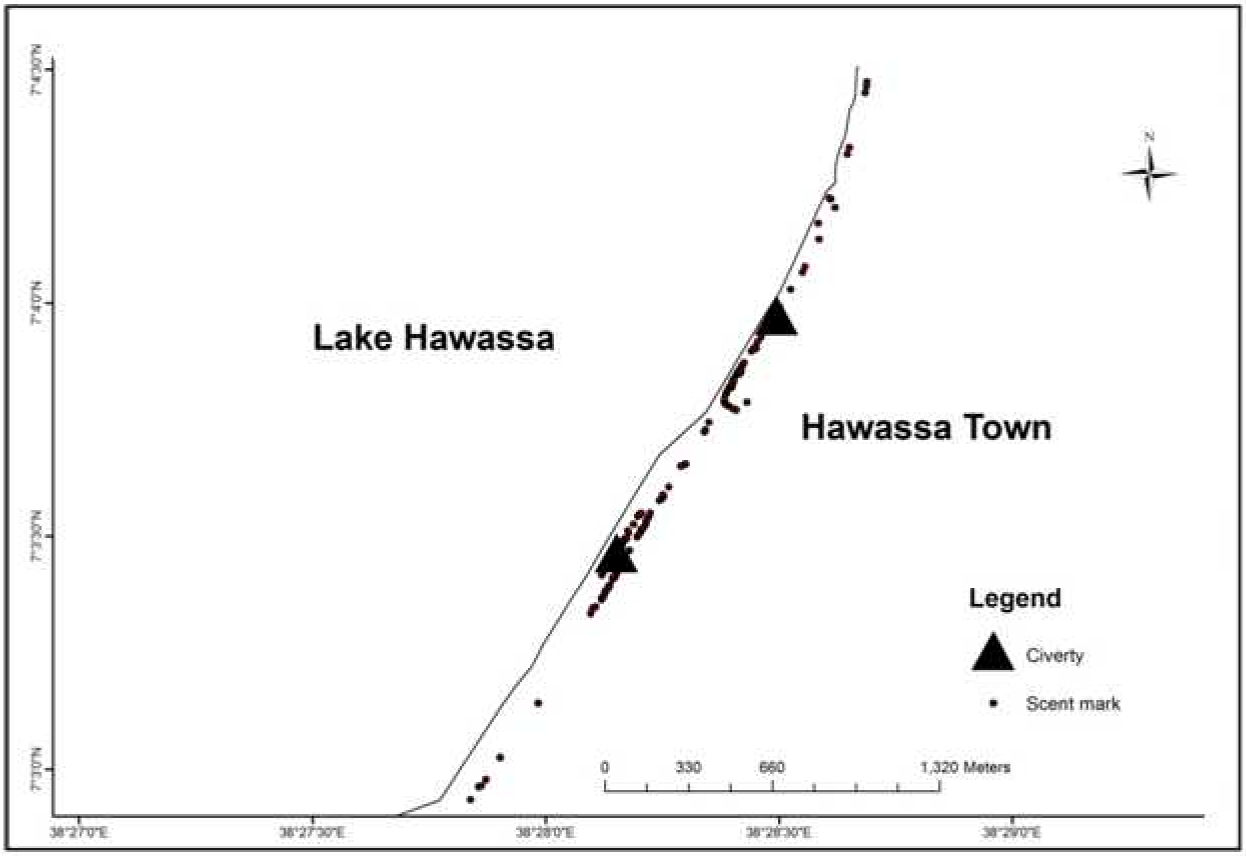

Figure 39. Distribution of scent marked objects around civetry and pathways in urban habitat

In this site, civets used only stem of plants for scent-marking. Most of the stems marked was wet (83.9%) and only 16.1% was on dry stems. They preferred smooth surfaced stem (81.9%) than rough surfaced stem (18.1%) for scent-marking ($\chi^2 = 87.111$, df = 1, $p < 0.05$). Average diameter of the scent-marked objects at the marked location was 4.9 cm (range = 0.8–31 cm).

Among the scent-marks recorded in the urban sites, 40.8% faced towards pathways. The direction of 21.1% of the scent marks was towards civetry, while 16.2% was circular (Fig. 40). Directions of scent-marks on scent-marked objects significantly varied between the different directions ($t = 3.0$, df = 5, $p < 0.05$). Only few sign-posts (1.4%) had markings towards two directions (opposite and other directions) simultaneously.

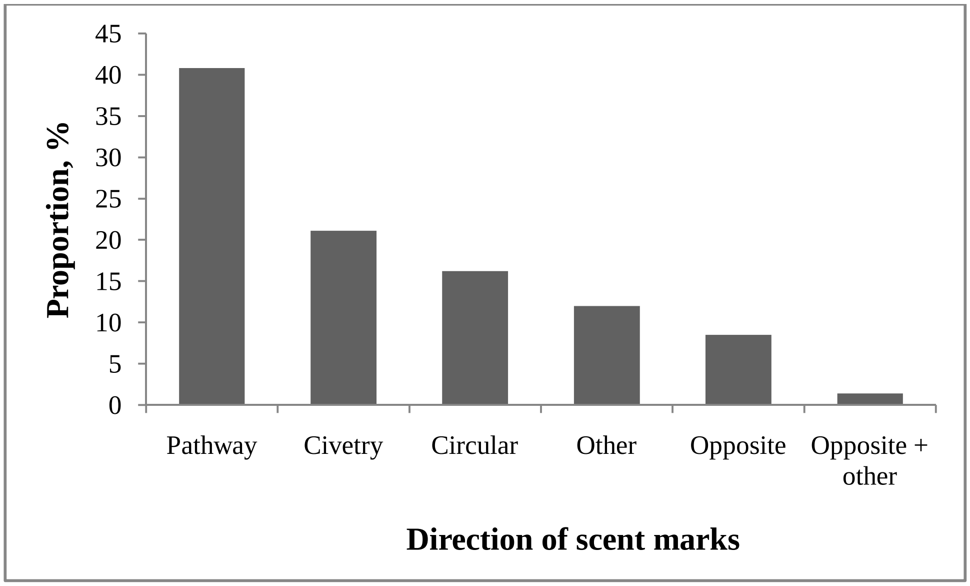

Figure 40. Proportion of directions of scents on the sign-posts in relation with pathway and civetry directions in the urban area

Civets established their sign-posts on an average distance of 0.43 m (range = 0–2 m) from nearest wildlife track in the urban area. Most of the sign-posts (95.8%) were distributed within 1 m distances from wildlife tracks in this habitat. Almost 10% of the sign-posts were established on pathways. They marked their secretion at the height range of 28−36 cm (mean = 31.1±0.46 cm) from the ground. The heights at which scent marks recorded were 31 cm (28.5%), 32 cm (24.3%), 28 cm (1.4%), 35 cm (1.4%) and 38 cm (0.7%) (Fig. 41).

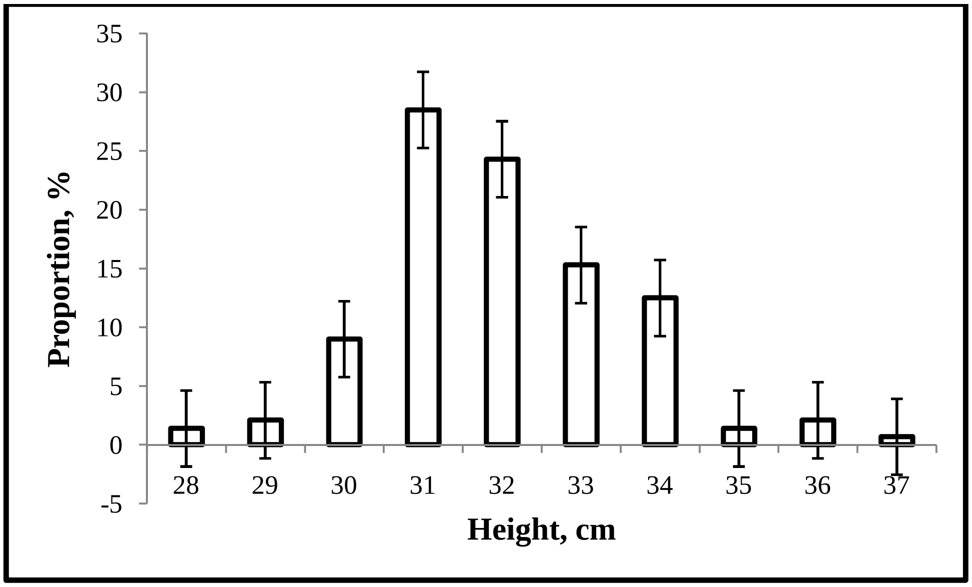

Figure 41. Height of scent-marked objects at which scent-marks were recorded in the urban area

In the urban area, 51.4% of the scents on the sign-posts had white color, followed by dark colored (20.8%) scents. Brown and mixed colored scents accounted for 17.4% and 10.4% of the sign-posts, respectively. On this site, whitish colored scents were more common than other types ($\chi^2 = 56.22$, df = 3, $p < 0.05$).

The weight of perineal glandular secretion in the urban habitat varied from 0.0001 g to 1.5110 g per scent-marked objects. Mean weight was 0.334±0.032 g in this sample site. Over 51% of the scent-marked objects were marked by less than 0.2 g of scents. Seven percent of the scent-marked objects were marked with high amount of scents (> 1.0 g). The quantity of the scent significantly varied between scent-marked objects in the urban area ($t = 10.406$, df = 143, $p < 0.05$).

Remarking of 9% of the scent removed sign-posts was observed on the same day of scent removal. Most of the scent removed sign-posts (74%) were remarked within 10 days after the removal of scents. Frequency of remarking was highly reduced from 16th day after removal of the scent. About 4.5% scent marks were not remarked after the removal of the scent (Fig. 42).

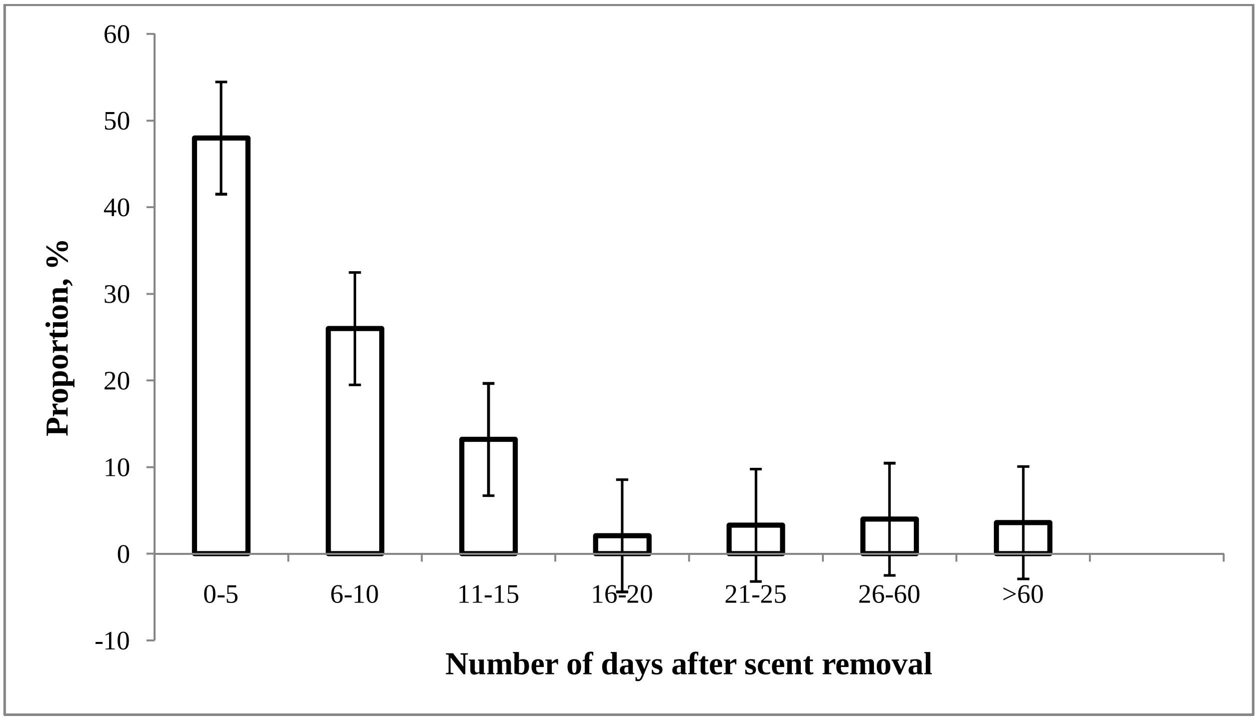

Figure 42. Remarking of perineal glandular secretion of the African civet after removal of scent from sign-posts in the urban area (>60 days represents scent-marked objects that were not marked after removal of glandular secretion during the whole investigation period)

During different sessions of remarking, the amount of scents available at the marked location varied on each sign-post. Relatively, higher amount of scent was available on the day of removal of the scent (mean weight = 0.33 g) and during the fifth remarking period (mean weight = 0.22 g). There was no uniform trend in the increase or decrease of the amount of scent during the different session of remarking (Fig. 43).

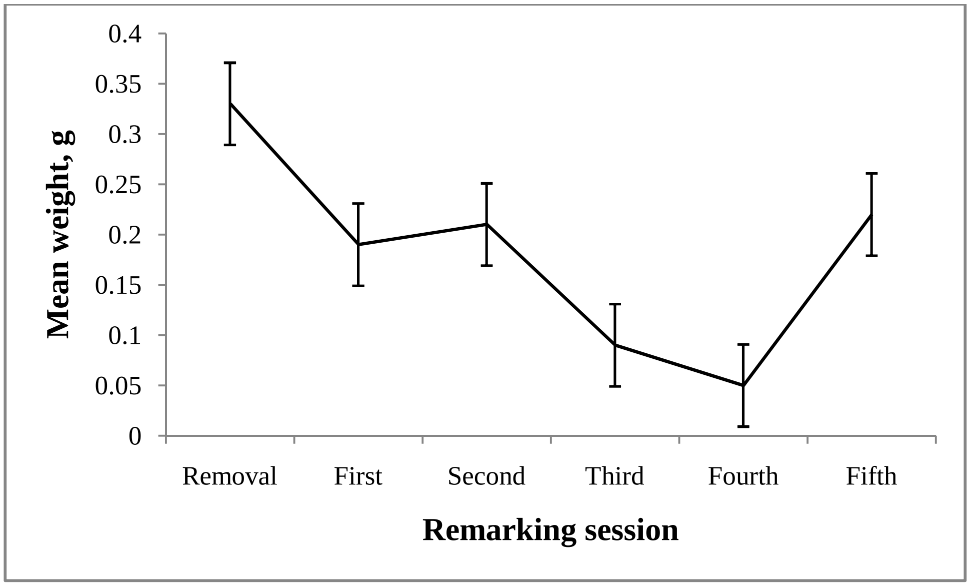

Figure 43. Mean weight of scent on the scent-marked objects measured at different remarking sessions in the urban habitat

4. DISCUSSION

4.1. Civetry

Some mammals position their latrine sites on specific locations. For example, badgers establish their latrine along ditches and fences and they need cover of canopy of close standing trees (Stewart *et al*., 2002). They also select woodlands when their population density is high, but they avoid arable land for establishing their latrines (Hutchings *et al*., 2001). Brown hyenas (*Parahyaena brunnea*) regularly establish their latrine sites at conspicuous landmarks (Gorman and Mills, 1984; Mills, 1990). Common otters (*Lutra lutra*) form their latrines along water edge (Kruuk and Hewson, 1978). Meerkat (*Suricata suricatta*) and yellow-mongoose (*Cynictis penicillata*) establish their latrines around their den, or they have barrow-based latrines (Ewer, 1973; Jordan, 2005). However, African civets maintain their civetries in various habitats such as dense forest, lake shore, bushy habitat, grassland, plantation, farmland, home garden and bare land. Scattered distribution of civetries across various habitat types in the current study area might indicate the potential of the African civets to use wide range of habitats. Also, distribution of defecation sites in a wide area is considered as "hinterland" scent marking strategy to optimize the scent mark distribution (Gorman and Mills, 1984). For example, in spotted hyena, scent marking sites and communal latrines are normally scattered throughout a territory and this "hinterland" scent marking strategy (Gorman and Mills, 1984) may be to optimize the distribution of communication signal over a large area with a limited amount of scent and time (Mills, 1990). Wide area usage might also show the potential of civets to adapt and thrive across different habitat types. Maintenance of civetries in home garden is likely due to the habituation of civets to survive in settlements (Ray *et al*., 2008).

In the current study area, higher density of civetries was recorded in farmland and natural forests. This variation may be related to differences in the distribution of food resources throughout the area, and the foraging strategy of civets (Delahay *et al*., 2007). Relatively higher number of civets was recorded in both the areas. Therefore, the density of civetries may be related with the number of individuals living in the area. Also, higher density of civetries might indicate the preference of the habitats by civets to these areas as observed in badgers (Balestrieri *et al*., 2009). Such variations in the density of civetries between habitats might be linked to resource-driven variation in spatial organization.

There is no uniform pattern in the formation of civetries. In some localities, it was highly dispersed and in other localities densely accumulated. For example, in urban and commercial farm areas civetries were sparsely distributed than the farmland and natural forest areas. The distribution of latrines may be affected by availability of food resources (e.g. badger, Harris and Yalden, 2008 and striped hyena, Macdonald, 1978), level of olfactory communication (e.g. in coyotes, Gese and Ruff, 1997) and density of animals (e.g. in badger, Hutchings *et al*., 2001). This behavior is often related to olfactory communication among individuals or groups as part of their reproduction, territory marking, and resource defense and evident in several carnivores. However, in some cases, latrines are simply be the result of animal social behavior, leading to aggregation (e.g., lek formation, repeated perch use, and sleeping sites). Scat disposal may also reflect a mammal's method of communication. The location and position of latrine therefore relates directly to the lifestyle of mammals. Comparatively, only few civetries were present in urban and commercial farm and this might be due to the occurrence of only few individuals of civets in these areas. Also, in degraded habitats, establishment of civetries may be limited due to variation in habitat structures of the area.

The age of civetries varied in the study area. Some of the civetries were used for longer period than others. Using a specific civetry for a longer period might indicate the stability of civet population in that area without disturbance or stability in the availability of resources for civets. In disturbed habitats, local emigration and establishment of new civetries from time to time are expected. For example, in commercial and urban areas, huge structures such as house and camp sites may be constructed in civetry areas. Civets that use these civetries might be forced to re-establish new civetries. Carnivores such as badgers use their latrine sites communally between members of family (Balestrieri *et al*., 2009). Among these, few individuals split when overpopulated and may form new latrine sites in another area. Civets also may follow similar patterns as badgers and individuals may move away when overpopulated and establish new civetries. But, this information needs further investigation for analysis of mechanisms and behavior of civetry formation in civets.

The present observation has shown that the suitable site for civetry establishment is along pathways of natural tracks or anthropogenic. Pathway preference for civetry formation is also reported from Jimma area (Wondimagegne Daniel, 2006) and Menagesha Suba State Forest (Bekele Tsegaye *et al*., 2008b). This behavior is also observed in other carnivores, for instance, badgers prefer linear structure for latrine formation (Balestrieri *et al*., 2009), common genet latrines were located primarily in conspicuously high features within the landscape (Espírito-Santo *et al*., 2007) and spotted hyenas prefer to form their latrine along conspicuous landmarks (Gorman and Mills, 1984). Coyotes often deposit their scat in the middle of trails or near the borders of their territories, where they can easily be seen by conspecfics (Elbroch *et al*., 2012). Behavior of civets defecating along visible areas is associated with advertizing their territory. They may prefer this site due to easy access to communicate with conspecifics. Also, it may reduce searching efforts and travel distance towards civetry from pathways and may help them to easily locate their civetry. Distance of civetries from the nearest pathway varied between habitats. The variation in the civetry distance may be associated with the structural variations in the habitats. In urban and farmland areas, pathways are planned and constructed for human use. Civets use the same pathways for their movements and maintaining civetries along these pathways. Naturally, pathways are formed by wildlife in the natural forests. Habitat structure in this area is relatively dense, and maintaining pathways might not be easy in human-mediated environments.

Open and dry areas were more preferred by civets to maintain civetries. Selection of open area for latrine is common among carnivores, for example in hyena and jackals (Gorman and Mills, 1984). The use of open space near the pathway for defecation could be for the use of the sites for communication purposes (Randall, 1979). However, meerkat unlike civets maintain their latrines under canopy at closed vegetation structure to increase scent-mark longevity by sheltering them from the evaporative effects of the sun and/or protecting them from occasional rains (Jordan, 2005). Civets might prefer open areas for defecation to get enough space for members to defecate, and the civetry may be visible to civetry users. Open areas for civetry formation may also be associated with predator avoidance strategy of civets during defecation. Some predators conceal themselves under canopy and ambush their prey. Use of dry area for defecation by civets is not clear and requires further detailed investigations on the civetry use. Ray *et al*. (2005) and

Dagnachew Melese *et al*. (2014) have reported that civets do not exist in the interior of dense forest. Our result also indicated the absence of civetries in the interior of dense forest. This type of vegetation structure may not be suitable for civets.

The pattern of defecation of civets was clumped. It may indicate some sort of hierarchy and kinship relationship between users of the same civetry. Dominant animals may defecate at the center of the civetry and at the top of the other feces. Sometimes close family members may form sub-civetry within a short distance from the main civetry. Young and new members may defecate in the surrounding area close to civetry to show respect or submissive behavior to elders.

The size of civetry users were not distributed uniformly within each habitat and between habitats. In badger and river otter, the number of latrine users varied between larine sites (Balestrieri *et al*., 2009). In food abundant areas, high number of latrines users were observed in otter (Kruuk and Hewson, 1978), while in badger, high number of users were observed in denning areas and wet season (Balestrieri *et al*., 2009). Users may be dependent on the size of each family using the civetry, and their potential of defending their territory. Civets are solitary animals; however, they may defend their civetry together and form group and territory association. More than one individual can use one civetry as one can observe scent marks at different heights around civetry.

Civetries in urban and commercial farm areas had higher number of civetry users when compared with civetries in farmland and natural forest areas. Both areas are modified and manipulated by humans. In these areas, formation of civetries may be limited by constraints such as unfavorable vegetation structure and restriction of movements by human disturbances.

Therefore, all civets in the area may use these few civetries. However, habitat structure in the farmland and natural forest areas are relatively more favorable and help civets to maintain more civetries.

A higher population density in the current study area is probably due to the increased abundance of food resources (Sandell, 1989), and favorable den sites. In modified habitats, the civets may be supplemented with anthropogenic food sources, as has been observed for skunks (Lariviere and Messier, 2001). These resources may facilitate immigration to the area by dispersing or transient animals (Coblentz and Coblentz, 1985). Availability of essential resources would also help to enhance reproduction. As has been observed in urban-omnivores (Prange *et al*., 2003), higher preference of African civets near anthropogenic food sources may also have a role in increasing population density.

4.2. Feeding ecology of civets

Characteristics of scats can reveal the origin of the scat, the season of deposition and the feeding habits and other activities of mammals (Elbroch *et al*., 2012). Shape of the civet feces was tubular and cylindrical. This type of fecal shape is freuquently shown on fruit and meat eating behavior of animals (Halfpenny, 2008). Significant variation was observed in the color of civet feces both spatially and temporally. Observed variations found in civet scats provide clues about the dietary variation and age of the animal (Halfpenny, 2008; Elbroch *et al*., 2012). For instance, black or dark scat indicates that carnivores were feeding on pure meat diet, while the same color of scats in herbivores indicates feeding on moist vegetation (Halfpenny, 2008). Gray feces indicates a mixture of hair and meat, brown color indicates vegetable matter, green carnivore scats indicates grass diet and white scats indicate older scats. Fruits dye scat have a rainbow of colors, a variety of other contents retain their color through digestion (Elbroch *et al*., 2012).

Civet scat was dominated by dark, brown, red, green, white and yellow colors, though the proportion of each varied between habitat and season. Dark colored feces indicates the feeding habit of civets on high protein material, while brown colored feces was due to feeding on fruits of cedar, which has brown pericarp. Red and green colored feces were due to the feeding on fruits of figs and avocado and grass, respectively. *Zea mays* diet resulted in whitish feces, while yellow colored feces were due to civets feeding on *C. papaya* and *C. edulis* fruits.

Spatially, whitish and dark colored feces were common in the commercial farm sites. This indicates highest proportion of maize in the diet of civets during the wet season and the highest proportion of meat diet during the dry season. In the farmland habitat, green and dark colored feces were commonly observed. It is due to preference of fruit of *P. americana* and grass diet in this habitat. Also, significant amount of high protein diet was included in this habitat, which resulted higher proportion of dark colored feces (Halfpenny, 2008). Higher proportion of brown and red colored feces in natural forest area may indicate the feeding habit of civets on fruits of *C. africana* and *Ficus* spp., respectively. Highest proportion of fish and other high protein foods in the diet of civets in urban area resulted in darkish colored feces.

Feces with solid texture were commonly observed during the current study period. Scat texture reflects the moisture content of animal's diet. Dry diets produce hard scat and wet diet produces soft or even loose scat (Halfpenny, 2008). Also the moisture content of scats depends on the season and the food item. When the vegetation is young and growing rapidly, the moisture content is high (Elbroch *et al*., 2012). During this time, the scat will be very soft. Civets mostly feed on matured fruits and animal flesh with hair and bones, which make most of the scat solid.

Remains of *P. americana*, *Z. mays*, grass, insects, hair, *C. africana*, *Ficus* spp. and *D. steudneri* were recorded as main undigested components in the scats of civets in different habitats. Parts of bones of fish were also observed as main undigested component of civet diet in urban area. Observing the remains of these diets as main undigested component in the scat of civet may indicate that civets focus on single type of food items when it is available. Civets may prefer this type of foraging strategy to conserve energy and time for searching for other food items and to save energy. Variation in the proportion of these main undigested food items between habitats may indicate the availability and preference of the specific food item in each area.

For carnivores, diet analyses mostly rely upon the morphological identification of undigested remains in the feces (Shehzda *et al*., 2012). Fecal analysis has been used to determine the diet of carnivores as this method is non-invasive, economical and suitable to study nocturnal and elusive animals. Scat analysis is commonly used to study dietary composition and preferences of animals (Putman, 1984). This technique was also used for African civet diet analysis in Jimma area (Wondimagegne Daniel, 2006), Wondo Genet (Ayalew Berhanu, 2007), Menagesha-Suba State Forest (Bekele Tsegaye *et al*., 2011b) and Tara Gedam (Abraham Abiyu *et al*., 2014). Scat analysis for civet dietary identification was effective as scat sample collection was easy and parts of most food items were clearly visible as undigested items.

African civets develop multiple way of feeding habits as a strategy to adapt various habitat types. They are frugivores as they feed on 15 species of fruits. Folivory, carnivory, insectivory and scavenging were also dietary strategies of civets. African civets were observed feeding on a variety of food items in the current study area. Its diet was composed of fruits, leaves, shoots, roots and tubers of different species of plants in addition to mammals, birds, fish and invertebrates. Variety of civet diet in this area (41 food items) is higher than the civet diet reported from Jimma area (Wondimagegne Daniel, 2006) and Menagesha-Suba State Forest area (Bekele Tsegaye *et al*., 2008b). A range of ecological and anthropogenic factors affect the diet composition and food preferences of carnivores (Grey *et al*., 2013). Habitat heterogeneity and modification in the present study area might have been responsible for the increase in the variety of food items of the diet of civets. In modified habitats, the variety as well as the quantity of the available food resources is high (Prange *et al*., 2003). Due to high degree of habitat heterogeneity such as farmland, urban habitat and natural forests in the present study area diversify the quantity and quality of the available resources for civets and these resources are available throughout the area (Quinn and Whisson, 2005). Also, civet diet can be supplemented from human food items associated with leftover and garbage bins, especially in the farmland and in the urban areas (Fedriani *et al*., 2001). Identification of aluminum foil and plastic materials in the scats of civets in the present study area might indicate that civets have been feeding on garbage (Halfpenny, 2008).

Civets mainly feed on fruits both in the number of fruits included (14 species of fruits) and in composition of the diet (36.9%). Dependence of small carnivores on fruit diet is also observed in martens, mongoose and palm civets (Corlett, 1998; Mudappa *et al*., 2010). Higher relative occurrence of fruit diet was due to high availability of fruits (both commercial and native) and relatively higher preferences of the animal towards fruit diet. But, African civet is less frugivorous than the brown palm civet (*Paradoxurus jerdoni*), which mainly feed on fruits of commercial and native tree species (fruits constitute 97% of brown palm civet diet) (Mudappa *et* *al*., 2010). African civets mainly consume fruits when availability is high and alternative foods are scarce. Unspecialized digestive system of carnivores (Eisenberg, 1989), physiological adaptation to a diet of fruits and their ability to feed opportunistically have probably enabled African civets to feed on fruits like the brown palm civets (Mudappa *et al*., 2010).

Preference of commercially important fruits such as *P. americana*, *C. papaya*, *Musa* sp. and *P. guajava* may be due to the nutrient content of these fruits. *Persea americana* is a fruit with high amount of lipid, amino acids, minerals, proteins and fatty acids (USDA, 1998). It is also known for its high content of oil (Ortiz *et al*., 2004). Trees of *P. americana* are common in the farmland and in the urban areas of the present study area. Relatively, availability of *P. americana*, *C. papaya* and *Musa* sp. is not seasonal. These fruits are available throughout the year, except for a brief period from July to August (personnel observation). These factors help civets to depend upon fruits both during the wet and dry seasons, in all the study sites except in the commercial farm. Availability of fruits of native tree species was seasonal, and thus the occurrence of these fruits in the diet of civets was also seasonal.

Variation in the composition of the variety of food items in the diet of the civets was high. Though civet diet comprised of diverse plant and animal species, only few items such as *P. americana*, *Ficus* spp., *Z. mays*, grass, insects and mammals were consumed more frequently than other items, even though some of which were more abundant in the study area. For example, vegetables and sugarcane are among the most abundant plants in the study area, but the proportion of these items in the diet of civet was less (sugarcane composed 2.6% and vegetables

2.4%). This might suggest that the food preference by civets, and the suitability of some diet for consuming and more digestibility than others.

Some mammals shift their diet based on the availability during the time when the preferred food item in scarce (van Schaik *et al*., 1993). African civets were observed feeding on leaf and shoot parts of different species of plants as strategic advantage to supplement their diet. Grasses were commonly used, and this suggests that civets use grasses for cleaning their intestine and facilitating digestion of protein rich diet (Wemmer and Watling, 1986; Elboch *et al*., 2012). Coffee growing is common among the community in the farmland area and around natural forest of the present study area, but leaf of coffee was observed only in two occasions. Coffee berry consumption was reported from Wollega (Marcone, 2004) and Jimma areas (Wondimagegne Daniel, 2006). However, civets rejected coffee berries in the present study area, probably due to the high availability of other fruits and food resources. Tubers of plants were also included in the diet of civets, which may help them to diversify the range of their diet and provide them with additional carbohydrates.

Civets also feed on animal matters either to supplement their nutrient requirement (e.g. protein) or as an adaptation to shift their diet during the period of fruit scarcity as observed in masked palm civets (Zhou *et al*., 2008). Remains of animal matters in the scats of civets indicate the behavior of civets preying upon small mammals (e.g. rodents), birds and chicken. It may also indicate the possibility of scavenging behavior of civets on human leftovers in human habitats and villages. Raiding on poultry is not common among the African civet (Kingdon, 1997; Wondimagegne Daniel, 2006; Bekele Tsegaye *et al*., 2008b), but parts of the chicken were identified from scats collected from the farmland, natural forest and urban areas. Civets may pick chicken waste after human use or they may get the whole body of chicken, which were dropped after dying due to disease or when infected by fungal disease, which is common in the present study area. Civets may also raid on chicken either in the farm or even capture from cages. Feeding on fish was only identified from scats collected from the urban area. It was probably due to availability of parts of fish in the waste or as civets might be scavenging in fishing areas around the lake.

Invertebrates were among important food items of civets, which constitute over 19% of the diet. Also invertebrates were in the scats of civets collected from all areas. It may be due to the wide spread distribution of invertebrates in all habitats and as they were easy for civets to collect while foraging.

Seasonally, there was no variation in the variety of food items identified from the scats. The current study area is modified by anthropogenic factors, and as a result, habitat structure may not vary significantly between wet and dry seasons, except in the commercial farm area, where vegetation structure during the wet season was highly different from the dry season. Slight changes in the habitat structure helped civets to get same resources during both seasons. But, compositional changes were observed in the proportion of some food items (e.g. *P. americana*, *Ficus* spp., vegetables, rodents and insects). This may be due to variation in the composition of available food resources. For example, *P. americana* fruit was present during both seasons, but the available fruits to civets were higher during the dry season, as there were more mature fruits this season. Civets are not arboreal animals, and hence, they depend upon dropped fruits.

Chances of dropping fruits are higher when it is well ripened than when the fruits are not ripened.

Few varieties of food items were identified from scats collected from commercial farm mainly due to less habitat variation. In this area, the land was mainly covered with single species of plants (maize) and scattered *Acacia* trees. Only fruits of three indigenous trees were seen in the diet of civets of this area. In areas where monoculture agriculture exists, the biological diversity of that area will be reduced (Altieri, 1995). Availability of food resources to civets in this habitat was limited and thus civets depend only on the available resources for survival. They also move to distance area to get fruits of *C. africana*, *Ficus* spp. and *D. steudneri* as these fruits are distributed around the wetland, located away from the civetries. *Zea mays* was the most common item among others, because the area was covered with maize, and thus, civets depended upon *Z. mays* diet. Although the area was covered with scattered *Acacia*, the importance of *Acacia* was insignificant in the diet of civets, mainly due to the non-accessibility of its parts (leaves or flowers) to civets. Civets also feed on animal matters in this habitat to supplement their diet. Mammals and invertebrates were among the common diet of civets in this area.

Temporal diet composition of civets varied between items. Variation in the composition of *Z. mays* in the diet was due to harvest of *Z. mays* during the dry season. The proportion of diet item was related with availability of specific diet item in the area. For example, proportion of fruits of *D. steudneri*, grass and herb was reduced during the dry season. Fruits of *D. steudneri* were available during the wet season and become less during the dry season. Commercial farm area is relatively drier than other sites and may retard the growth of fresh grass and herbs. Hence, the proportion of these items was reduced in the diet of civets.

Comparison between the four study sites revealed highest diversity of food item in the farmland area. Farmland area was characterized by mixed type of cropping, stock farming, human settlement and home garden with various types of fruits. These heterogenic habitat structures in the farmland area were responsible for the diversity and quality of food resources for civets. Habitats with heterogenic structures support wildlife with their food requirements as well as provide them good den sites (Quinn and Whisson, 2005).

Seasonal diet variation was not observed in this habitat. But the effect of season in the feeding behavior of civets was reported from both Jimma area and Menagesh-Suba State Forest (Wondmagegne Daniel, 2006; Bekele Tsegaye *et al*., 2008b). As in the farmland area, the farm was irrigated during the dry season, changes in the habitat structure between seasons was insignificant. Relatively, variation was observed in the composition of some food items, mainly due to variation in the quality of each item. Fruits on each tree were more during the dry season than during the wet season. Fresh leaves and shoots of grasses were available during the wet season. Abundance of insects and snail was more during the wet season.

Relatively, moderate number of food items was included in the diet of civets in the natural forest area. Fruits, like in other sites, were the most preferred food item in this area. Civets preferred fruits due to its availability, suitability, quality and easy accessibility to animals. Presence of more *Ficus* spp. and *C. africana* trees in this habitat provided civets with the required quantity of fruits, and hence they need not have to travel long distances in search of food.

The proportion of animal matter in the diet of civets was higher in the natural forest habitat than in the other three sites. Civets in this area consumed more animal matters either due to the availability of prey population or to compensate the scarcity of fruits. Natural forest provides favorable and balanced niche for the existence of various groups of animals. Thus, the availability and diversity of prey animals (mammals, birds and invertebrates) are high in this area. There were 27 and 28 food items in the diet of civets during wet and dry seasons in natural forest habitat, respectively. Significant seasonal change was seen in the feeding habit of civets in this site. The area is covered with different species of plants that are available throughout the year. Further, the area was supplemented with water from streams and irrigation during the dry season. Therefore, due to these factors, the vegetation composition of the area is almost similar throughout the year and this is reflected in the food habits of civets with no significant difference in the feeding patterns of civets in the present study area. However, compositional variation was seen in *Z. mays*, bone and meat, millipedes, *P. americana* and rodents mainly due to variability in the quality of these items with respect to season.

The urban area is highly manipulated by human activities, but it is suitable to civets (Dagnachew Melese *et al*., 2014). Modification of the area supplements civets with some additional foods such as garbage and leftover in picnic areas. Also modified habitat increases abundance of prey items such as rodents, insects and mollusk (Quinn and Whisson, 2005). It is already known that urban areas are among suitable habitats for urban dwelling animals such as badger (Judge *et al*., 2013) and raccoon (Murray, 2002).

Occurrence of parts of fish in the scats revealed the availability of fish in this habitat. Fish is the most preferred diet of civets than mammals, invertebrates, birds and tubers in the urban area, probably due to high density of dropped fish parts along the lake shore. Fishing is a common practice along the shore of Lake Hawassa and is carried out throughout the year, but the level of fishing varied between different periods of the year. For example, intensive fishing is observed during the Ethiopian Orthodox Christian fasting period (February to April) and during te summer season (August and September). During these periods, the availability of rejected fish parts are also high

4.3. Seed dispersal

Fruit eating mammals are known for mutualistic association as they play a major role in seed dispersal. African civets deposit seeds through feces on their civetries. These plants germinate on civetries and thus, civets can influence the reproductive successes of plants and their population dynamics (Stiles and Rosselli, 1993; Muddapa *et al*., 2010). Civets as other frugivorous animals can disperse seeds of various plant species through their feces (Jordano *et al*., 2007; Nakashim and Sukor, 2009; Muddapa *et al*., 2010). This may enhance the ability of secondary seed dispersers and post-dispersal seed predators to locate seeds. The main behavioral characteristics of civets that help seed dispersal of plants is clumped pattern of fecal deposition, improvement of soil nutrients at civetry, high moisture at civetry, the number of seeds removed per defecation, selection of open site for defecation, ability of civets to thrive in fragmented habitats and in human settlements and feeding behavior of civets on matured fruits. The intensity of digestion and level of seed mastication may also affect the efficiency of seed dispersal. The role of African civets as seed disperser was emphasized in previous studies (Rabinowitz, 1991; Wondmagegne Daniel, 2006; Bekele Tsegaye *et al*., 2008b).

Cordia africana, *C. papaya*, *P. guajava*, *Ficus* spp., *Z. mays*, *D. steudneri*, palm, *Cucurbita* sp., *C. esculenta*, *C. edulis*, *Eucalyptus* spp., *S. nigra* and tomato seedlings were observed on civetries in the present study area. Seeds of these fruits were dropped unaffected and germinated in various locations away from the parent plants. *Cordia africana*, *D. steudneri*, palms and *Ficus* spp. seedling were observed on civetries located in the natural forest, farmland and urban areas. This may have important role in maintaining and regeneration of trees on farmlands and fragmented landscapes. Once germinated, the seedling of most trees will be protected by farm owners. Farmers keep the seedling because these trees are valuable by providing shade for plants, which prefer to grow under shade (e.g. coffee) and improve soil quality (e.g. dropped leaf of *C. africana* and *D. steudneri* decompose and fertilize the soil under the canopy). Thus, it may play a major role in integrated agro-forestry practice. On the other hand, civets move agricultural crops such as *Cucurbita* sp., *Z. mays*, *C. edulis*, tomato, *C. esculenta* and *P. guajava* to natural forest. This movement of agricultural crops to natural forest area may facilitate *in-situ* conservation of these fruits. If the crops are capable of maintaining themselves in the natural forest, it helps to maintain genetic diversity of local crops in the long-run to control the current genetic erosion of agricultural crops by selective breeding for higher yield.

Civets may move consumed seeds or part of plants from forest to forest, forest to farmland, farmland to farmland or farmland to forest. The chance of seed dispersal will be determined by the behavior and home range of civets. Movement of seeds from farmland to farmland may increase variability of fruits and some crops such as taro. Direction of consumed seeds across habitats is indicated in Figure 44.

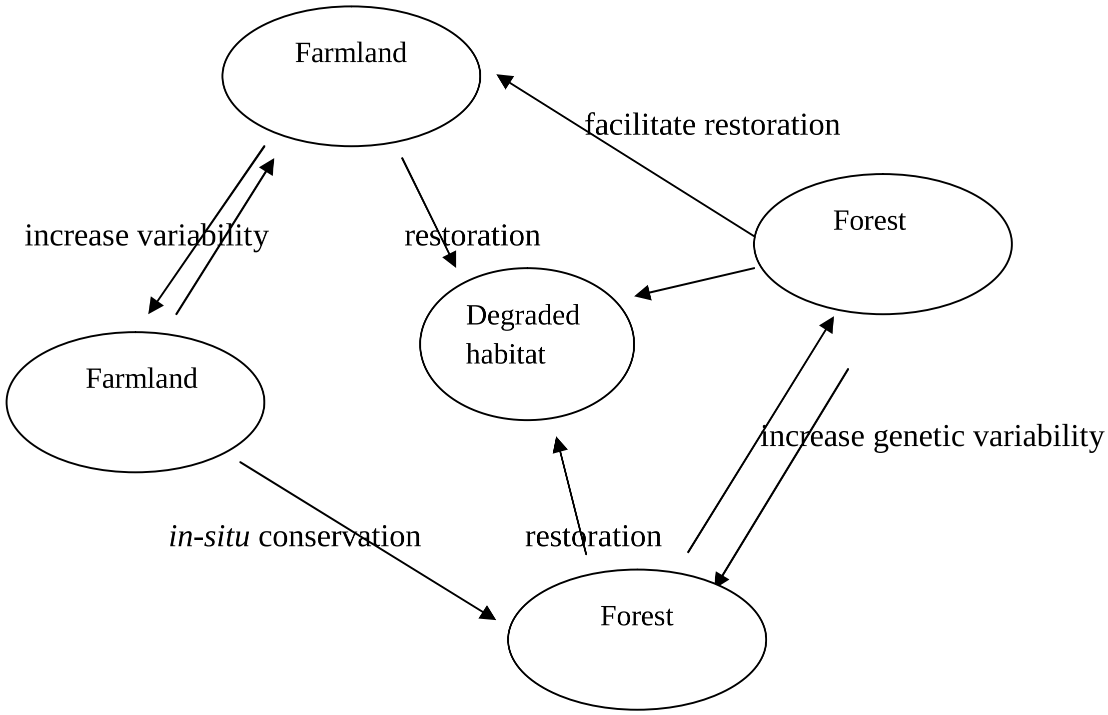

Figure 44. Movement of consumed seeds or parts of plants across the available habitats

Consumed seed movements not only have positive effects on natural ecosystems, but there may have also a probability of negatively affecting the natural ecosystem. There is a probability of dispersing invasive species of plants from farmland or degraded areas to natural forest and *vice-versa*, which may affect the health of the ecosystem. For example, *Lantana camara* is among an invasive species, which mainly affects agriculture, forest margins, riparian and grassland habitats (Sharma *et al*., 2005), and can taken from one habitat to another habitat through the feces of animals. However, it was not identified from the diet of civets during the present study area.

Frequency of tomato, *C. esculenta* and *Cucurbita* sp. was limited in the diet of civets, but the seedlings of these plants were recorded at least in two habitats. *Colocasia esculenta* was distributed along riverine habitat and civets may obtain it from this habitat. There is no report on digging of civets to get tuber plants, thus they probably get *C. esculenta* and other tubers from human leftovers. *Colocasia esculenta* dispersal by palm civets was reported in earlier by van Leeuwen. The smell of *C. esculenta* is reminiscent of an overripe pineapple. The strong ripe fruit smell of *C. esculenta* is of high dispersal value as common palm civets disperse their seeds (Bartels, 1964), Considering the habit of common palm civets, some authors have suggested that palm civets perhaps play an important role in the early domestication of *C. esculenta* by dispersing the seeds around human settlements, and hence facilitating selection by early settlers (Walker, 1968; Ducker, 1975; Lekagul and McNeely, 1977).

Persistence of African civets in fragmented forest and human settlement areas can help them to play a major role in restoration of degraded fragments in these landscapes. Thus, they are important in seed dispersal, affecting plant gene flow and maintaining the heterogeneity of the habitat (Mudappa *et al*., 2010; Abraham Abiyu *et al*., 2014).

Fecal deposition pattern of civets affects the physical and chemical properties of soils. All analyzed parameters showed an improved soil quality in civetry locations. Other studies on mammals also showed that fecal deposition enhances soil properties by adding nutrients to the soil. For instance, droppings of rabbit (*Oryctolagus cuniculus*) improved soils in Spain by accumulating high nitrogen (as NH_{4+} and NO_3), phosphorus, organic carbon, potassium and magnesium (Willott *et al*., 2000). The latrines of antelopes play an important role in ecosystem enrichment of certain areas in nutrients (Lunt, 2011). Duiker and steenbok defecate in exposed sites, generally on sandy soils, while klipspringer prefers rocky outcrops. They enrich these nutrient-deficient areas (Lunt, 2011). African civets defecate in a single location for a long period, which causes accumulation of fecal materials. The undigested parts of the diet enter the ecosystem through the process of decomposition. Although latrines/civetries only comprised smaller portion of the ground surface area in each community, they make significant localized contributions to soil fertility and create suitable microhabitats for germination, establishment and maintenance of plant seeds (Willott *et al*., 2000; Lunt, 2011).

4.4. Scent marking

Scent marking among carnivores probably serves to signal reproductive condition and maturity (Mykytowyez, 1971; Balakrishnan and Alexander, 1985; Muller and Manser, 2008). In solitary species like civets, scent marks could assist a female's reproductive effort in two ways; first by informing males of her reproductive state and second by assisting a potential mate to locate her (Xavier, 1994a). Males are more attracted to odors of oestrous females than non-oestrous females (Brown, 1979; Gorman and Trowbridge, 1989). Investigations around civetry and non-civetry areas have revealed high densities of scent marks around civetries and pathways. Civets use civetries as stations for olfactory communication as seen in other carnivore latrines, e.g. in badger (Delahay *et al*., 2007), common genet (Esprito-Santo *et al*., 2007), hyena (Gorman and Milles, 1984; Halsman *et al*., 2010), meerkat (Jordan, 2005) and raccoon (Hirsch *et al*., 2014). High density of scent marks around civetries shows the possibilities of group defense behavior of core area around the civetry (Jordan *et al*., 2007) or for individual identification (Linklater *et al*., 2013) and attracting mates (Alberts, 1992). Although civets are considered as solitary animals (Kingdon, 1997; Nowak, 1999), the behavior of sharing the same civetry between different individuals might show some sort of social interactions at least for a brief period around the civetry.

Variation in the height of scent marked objects around civetries indicate the age composition of civetry users, probably family members with different age group. In few sign-posts, scent marks were observed at two different heights on the same sign-post. Johanston *et al*. (1995) and Ferkin (1999) have explained this situation as "overmarking". Overmarking involves placing of a scent mark directly on top of an existing mark. Overmarking may indicate dominance of one member over another as observed in meerkat (Jordan *et al*., 2007). During overmarking, the dominant individual not only shows its dominance by marking on top of the other mark, but also indicates its dominance by putting high quantity of scent marks and by "countermarking" (Hurst, 1987). Countermarking is depositing many marks around the vicinity of an overmarked sign-post. Overmarking provides reproductive advantage by increasing preference of females to males, whose scent is on the top (Johnston *et al*., 1997).

Variation in the density of scent marks between civetries associates with the number of civets using each civetry. Civetries with higher number of users are expected to have more scent marks than civetries with few users. Density of scent marks was related with the number of latrine users in meerkat (Jordan, 2005) and badgers (Balestrieri *et al*., 2009). Also, higher densities of scent marks reveal high level of information exchange between members of the civetry users. For example, latrines in resource shortage areas may contain more scent marks to defend those resources in short supply, as reported for brown hyena (Hulsman *et al*., 2010). Variation in the density of scent marks were observed in non-civetry locations, especially along pathways. Randall (1979), Bekele Tsegaye *et al*. (2008a) and Wondimagegne Daniel *et al*. (2011) have reported the importance of pathways as communication areas for African civets. Scent marks consist of both odor and visual cues (Gese and Ruff, 1997), that they may mark at conspicuous areas. Civets may prefer scent marking objects along their pathways, as these areas have higher chance of visibility for conspecifics.

In the farmland and natural forest areas, scent marks were more distributed around civetries than in non-civetry locations. But, in the urban area, more scent marks were distributed along pathways than around civetry sites. These distributional variations of scent marks between different habitats can be explained by structural and landscape variations in the respective sites. In the urban site, the landscape has linear feature due to the existence of water bodies on both sides of the site. This linear structure of the site may help civets to scent mark on the available sign-post, following the structure. Civetries close to the den site or breeding area, possess additional scent marks to advertize their status. For example, in an earlier study, one of the civetries was in close proximity to the den site of a radio-collared civet in the Wondo Genet area (Ayalew Berhanu *et al*., 2013).

Relatively lower density of scent marks were recorded from the civetry and the non-civetry sample sites in farmland habitats than in natural forest and urban areas. This area is modified for human use, which may create suitable habitat for civet survival as suggested by Dagnachew *et al*. (2014). Level of defending for territory or other resources is minimized when the resources are available (Gosling, 1982; Richardson, 1993). Thus, civets in this habitat maintained only few scent marks for defending resources due to availability of sufficient resources. Scent mark density variation between civetry and non-civetry sites in this habitat was mainly related with variations in the level of communication in both sites or it may be an indication of defending core areas of the home ranges as seen in banded mongoose (Muller and Manser, 2008). High density of scent marks in core areas of the home range might indicate higher utilization of these areas for mating, feeding and denning. The distribution of scent marks is consistent with spatial distribution of individuals (Muller and Manser, 2008). As more individuals were using each civetry, they scent mark more sign-posts in the civetry site than in the non-civetry site.

African civets used different objects for scent marking in the present study area. Investigation on scent marking patterns of civets in other areas by Bekele Tsegaye *et al*. (2008a) and Wondimagegne Daniel *et al*. (2011) revealed that they used different environmental objects such as stem, leaf, pole and metallic objects for scent marking. Civets in farmland area preferred the stem of eucalypts tree for scent marking than other objects. Preference for *Eucalyptus* for scent marking might be related with the availability of this tree in the area. Selection of stem for scent marking might be due to the suitability of the stem and it also enhances the probability of visibility of scent marked sites by conspecifics.

The immediate response of remarking on some sign-posts may be an indication for those sign-posts, which are more frequently used for communication by civets. For instance, those sign-posts, which are marked for the purpose of territorially may be marked more frequently than sign-posts related to reproductive behavior. The non-remarked sign-posts during the study period may be associated with reproductive behavior of the civets. As reproductive behavior is seasonal in civets, the removal of these sign-posts might not affect the behavior of the owner during the non-breeding season.

5 CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The findings of this investigation have suggested that civetries are important sites for defecation, olfactory communication and deposition and dispersal of seeds of different species of plants. Thus, civetries in addition to the role of communications, facilitate seed dispersal, which in turn increases genetic variability and heterogeneity of plant community.

Farmland and urban areas contained higher density of civets during the present study period. African civets prefer modified habitat as such areas have heterogenic resources, and less competition from larger carnivores. Lower density of civets in natural forest area might be associated with high level of competition between sympatric species. Also the result indicated the potential of non-protected areas for conservation of civets. However, effects of modified habitats on the population of civets in the long-term are not known.

Diet variability was observed between habitats, but the effect of season was insignificant. Most food items were from anthropogenic sources in farmland, natural forest and urban areas, which may affect civet population in the long-term when good waste disposal and management are effectively implemented.

Civetries are distributed across a range of habitat types. Maintenance of civetries around home garden and farmland might have some implication on human health, as civets are close to human and domestic animals. Civets serve as reservoir for certain disease such as rabies, may affect wildlife and *vice-versa*.

Feeding habit, wide habitat range and defecation patterns of civets may play significant role in soil nutrient improvement and seed dispersal. Deposition of feces on the same place change physical and chemical properties of soil in civetries, which facilitate germination of seeds and establishment of germinated seedlings. Their role in seed dispersal might play a role in restoring degraded and fragmented landscapes, regeneration of trees in farmlands and improving genetic diversity of forests.

5.2.Recommendations

The present investigation has revealed only the density, distribution and number of users of each civetry in the study area. However, the pattern of civetry use, time of visit and presence of any social interaction in the civetry is not known. Thus, detailed investigation on civetries using camera trapping and radio telemetry is important.

More civet population density was observed in farmland and urban areas. Sustainability of resources in modified areas is not guaranteed and thus may affect civet population negatively in the long-term. Hence, studying the effect of modified habitats on the ecology and biology of civets and designing effective management strategy is mandatory to facilitate conservation of civets in these landscapes.

African civets are among effective seed dispersing mammals; however, detailed investigation on the viability of defecated seeds, rate of establishment of seedling and interaction with secondary seed dispersers is recommended.

The present investigation has revealed scent marking pattern of the African civet in different habitats. But, separation, quantification, chemical characterization of perineal glandular secretion and interpretation of each component may help to understand the behavior of civet and help to reduce conflicts between civets and humans and may provide an insight into better management practices for conservation of civets.

Researchers use scent station analysis as indices of population estimate for various carnivores. Thus, developing techniques for scent station analysis of civets is important to estimate population density of civets, which can be effective for estimating the abundance of secretive and nocturnal animals.

There is no information in civet−human interactions at civetry sites. Civetries in home gardens and farms may cause diseases, which has implication on human and wildlife health. Therefore, detailed parasitological analysis on civetries and mode of transmission of parasites is important to prevent zoonotic diseases.

6. REFERENCES

Abrham Abiyu, Demel Teketay, Glatzel, G. and Gratzer, G. (2014). Tree seed dispersal by African civets in the Afromontane Highlands: too long a latrine to be effective for tree population dynamics. African Journal of Ecology published on line on January, 2015 at DOI: 10.1111/aje.12198

Afework Bekele and Yalden, D.W. (2013). *The Mammals of Ethiopia and Eritrea*. Addis Ababa University Press, Addis Ababa.

Alberts, A. C. (1992). Constraints on the design of animal communication systems in terrestrial vertebrates. *Am. Natur.* **139**: 62−89.

Altieri, M.A. (1995). *Agroecology: The Science of Sustainable Agriculture*. West view Press, Boulder.

Angelici, F.M., Luiselli, L., Politano, E. and Akani, G.C. (1999). Bushmen and mammal fauna: a survey of the mammals traded in bush-meat markets of local people in the rainforest in southeastern Nigeria. *Anthropozoologica* **30**: 51−58.

Ayalew Berhanu (2007). *Feeding Ecology, Scent Marking and Movement Patterns of the African Civet in Wondo Genet Forest, Ethiopia*. M.Sc. Thesis, Addis Ababa University, Addis Ababa.

Ayalew Berhanu (2010). *Species Composition, Abundance, Diversity and Threats to Bird Community in Hawassa Lake and Town, Ethiopia.* Independent Study Paper, Addis Ababa University, Addis Ababa.

Ayalew Berhanu, Afework Bekele and Balakrishnan, M. (2013). Home range and movement patterns of the African Civet *Civettictis civetta* in Wondo Genet, Ethiopia. *Small Carniv. Conserv*. **48**: 83−86.

Balakrishnan, M. and Alexander, K. M. (1985). Source of body odor and olfactory communication in south Indian mammals. *Ind. Rev. Life Sci.* **5**: 277−313.

Balestrieri, A., Remonti, L. and Prigioni, C. (2009). Habitat selection in a low-density badger *Meles meles* population: a comparison of radio-tracking and latrine surveys. *Wildl. Biol*. **15**: 442−448.

Barja, I., Silván, G., Martínez-Fernández, L. and Illera, J. (2011). Physiological stress responses, fecal marking behavior and reproduction in wild European pine martens (*Martes martes*). *J. Chem. Ecol.* **37**: 253–259.

Bartels, E. **(**1964). On *Paradoxurus hermaphroditus* (Horsfield 1824). *Beaufortia* **19**: 193−201.

Bearder, S.K. and Randall, R.M. (1978). The use of fecal marking sites by spotted hyena and civets. *Carnivore* **1**: 32−48.

Beebee, T. and Rowe, G. (2005). *An Introduction to Molecular Ecology*. Oxford University Press, New Delhi.

Bekele Tsegaye (2006). *Ecological Studies on African Civets (Civettiscts civetta)*. M. Sc. Thesis, Addis Ababa University, Addis Ababa.

Bekele Tsegaye, Afework Bekele and Balakrishnan, M. (2008b). Feeding ecology of the African Civet *Civettictis civetta* in the Menagesha–Suba State Forest, Ethiopia. *Small Carniv. Conserv*. **39**: 19−24.

Bekele Tsegaye, Afework Bekele and Balakrishnan, M. (2008a). Scent-marking by the African Civet *Civettictis civetta* in the Menagesha–Suba State Forest, Ethiopia. *Small Carniv. Conserv*. **38**: 29–33.

Birdlife International (2009). *Important Bird Area Factsheet: Lake Awassa, Ethiopia*. Accessed from http://www.birdlife.org on 5/5/2010

Bothma, J. D. (1971). Food habits of some carnivora (Mammalia) from Africa. *Ann. Trans. Mus*. **27**: 15−25.

Brown, R. E. **(**1979). Mammalian social odors: A critical review. **In**: *Advances in the Study of Behavior*, pp. 103−162, (Rosenblatt, J. S., Hinde, R. A., Beer, C. and Busnel, M.C., eds). Academic Press, New York.

Campbell, D.J. and Henshall, K. (1991). Bulk density. **In**: *Soil Analysis Physical Methods*, pp, 329−366, (Smith, K.A., Mullins, C.E., eds). Marcel Dekker Inc., New York.

Chapman, J.D. and White, F. (1970). *The Evergreen Forests of Malawi*. Oxford University Press, Oxford.

Clapperton, B. K**. (**1989). Scent-marking behavior of the ferret, *Mustela furo* L. *Anim. Behav*. **38:** 436–446.

Coblentz, B.E. and Coblentz, B.A. (1985). Reproduction and the annual fat cycle of the mongoose *Herpestes auropunctatus* on St. Jhon, U.S.A. Virgin Islands. *J. Mammal*. **66**: 560−563.

Colon, C.P. (2002). Ranging behavior and activity of the Malay civet (*Viverra tangalunga*) in a logged and an unlogged forest in Danum Valley, East Malaysia. *J. Zool. Lond.* **257**: 473−485.

Colyn, M., Dufour, S., Condé, P. C. and Van Rompaey, H. (2004). The importance of small carnivores in forest bushmeat hunting in the Classified Forest of Diécké, Guinea. *Small Carniv. Conserv.* **31**: 15–18.

Corlett, R. T. (1998). Frugivory and seed dispersal by vertebrates in the Oriental Indomalayan Region. *Biol*. *Rev*. **73**: 413−448.

Croes, B. M., Laurance, W. F., Lahm, S. A., Tchignoumba, L., Alonso, A., Lee, M., Campbell, P. and Buij, R. (2006). The influence of hunting on anti-predator behavior in central African monkeys and duikers. *Biotropica* **39:** 257−263.

Croes, B., Buij, R., de Longh, H. and Bauer, H. (2008). Management and Conservation of Large Carnivores in West and Central Africa. Proceedings of an international seminar on the Conservation of small and hidden species, Maroua.

Dagnachew Melese, Suryabhagavan, K.S., Melakneh Gelet and Balakrishnan, M. (2014). Remote sensing and geographic information system-based African civet habitat mapping in Andracha, Ethiopia. *J. Appl. Rem. Sense.* **8**: 1−12.

Delahay, R.J., Ward, A.I., Walker, N., Long, B. and Cheeseman, C.L. (2007). Distribution of badger latrines in a high-density population: habitat selection and implications for the transmission of bovine tuberculosis to cattle. *J. Zool*. **272**: 311−320.

Demeke Admassu (1996). The breeding season of tilapia, *Oreochromis niloticus* L. in Lake Awassa (Ethiopian rift valley). *Hydrobiologia* **337:** 77−83.

Do Linh San, E., Ferguson, A.W., Belant, J.L., Schipper, J., Hoffmann, M., Gaubert, P., Angelci, F.M. and Somers, M.J. (2013). Conservation status, distribution and species richness of small carnivores in Africa. *Small Carniv. Conserv*. **48**: 4−18.

Do Linh San, E.**,** Ferrari, N. and Weber, J.M. (2007). Spatio-temporal ecology and density of badgers *Meles meles* in the Swiss Jura Mountains. *Eur. J. Wildl. Res.* **53**: 265−275.

Ducker, G. (1975). Viverrids and Arrdwolves. **In**: *Grzimek's Animal Life Encyclopedia* **12**: 144−184.

Eisenberg, J. F. (1989). An Introduction to the Carnivora. **In**: *Carnivore Behavior, Ecology and Evolution*, pp, 1-9, (Gittleman, J. L., ed.). Cornell University Press, Ithaca.

Eisenberg, J.F. and Kleiman, D.G. (1972). Olfactory Communication in Mammals. *Annu. Rev. Ecol. Syst*. **3**: 1-32.

Elbroch, L.M., Kresky, M. and Evans, J. (2012). *Field Guide to Animal Tracks and Scat of California*. University of California, California.

Eriksson, H. and Stem, M. (1987). *A Soil Study at Wondo Genet Forestry Resources Institute, Ethiopia.* Swedish University of Agricultural Sciences, International Rural Development Centre, Uppsala.

Eshetu Yirdaw (2002). *Restoration of the Native Wood Species Diversity, Using Plantation Species as Faster Trees, in the Degraded Highlands of Ethiopia***.** PhD Dissertation, University of Helsinki, Helsinki.

Espírito-Santo, C., Rosalino, M.L. and Santos-Reis, M. (2007). Factors affecting the placement of common genet latrine sites in a Mediterranean landscape in Portugal. *J. Mammal*. **88**: 201−207.

Estes, R.D. (1991). *The Behaviour Guide to African Mammals: Including Hoofed Mammals, Carnivores and Primates*. University of California Press, Berkeley.

EWCO (1999). *General Information on Oromia Wildlife Resource*. Ethiopian Wildlife Conservation Organization, Addis Ababa.

EWCO (2002). *A Package on Highly Profitable Animal and Animal Products*. Ethiopian Wildlife Conservation Organization, Addis Ababa.

Ewer, R. F. and Wemmer, C. (1974). The behaviour in captivity of the African civet, *Civettictis civetta* (Schreber, 1776). *Zeitsch. fiir Tierphy*. **34**: 359−394.

Ewer, R.F. (1973). *The Carnivores*. Cornell University Press, Ithaca.

Fedriani, J.M., Fuller, T.K. and Sauvajot, R.M. (2001). Does avalaiblity of anthropogenic food change densities of omnivorous mammals? An example with coyotes in southern California. *Ecography* **24**: 325−331.

Ferkin, M. H. (1999). Meadow voles (*Microtus pennsylvanicus*, Arvicolidae) over-mark and adjacent-mark the scent marks of same-sex conspecifics. *Ethology* **105**: 825−837.

Fiorelli, L.E., Ezcurra, M.D., Hechenleitner, E.M., Arganaraz, E., Taborda, J.R.A., Trotteyn, M.J., von Baczko, M.B. and Desojo, J.B. (2013). The oldest known communal latrines provide evidence of gregarism in Triassic megaherbivores. *Scient. Rep.* **3**: 3348−3356.

Foster, R.J., Bart J. Harmsen, B.J. and Doncaster, C.P. (2010). Sample-size effects on diet analysis from scats of jaguars and pumas. *Mammalia* **74**: 89−93.

Friis, I. (1986). The forest vegetation of Ethiopia. *Symbolae Botanicae Upsalienses* **26**: 31–47.

Friis, I**. (**1992). *Forests and Forest Trees of Northeast Tropical Africa. Their Natural Habitats and Distribution Patterns in Ethiopia, Djibouti and Somalia.* Kew Bulletin Additional Series XV. London.

Gaubert, P. and Cordeiro-Estrela, P. (2006). Phylogenetic systematics and tempo of evolution of the Viverrinae (Mammalia, Carnivora, Viverridae) within feliformians: implications for faunal exchanges between Asia and Africa. *Mol. Phylogenet. Evol*. **41**: 266–278.

Gaubert, P. and Veron, G. (2003). Exhaustive sample set among Viverridae reveals the sister-group of felids: the linsangs as a case of extreme morphological convergence within Feliformia. *Proc. R. Soc. Lond. B*. **270**: 2523–2530.

Gaubert, P., Taylor, P. and Veron, G. (2005). Integrative Taxonomy and Phylogenetic Systematics of the Genets (Carnivora, Viverridae, *Genetta*): A New Classification of the most Speciose Carnivoran Genus in Africa. **In**: *African Biodiversity: Molecules, Organisms, Ecosystems*, pp. 371–383, (Huber, B. A., Sinclair, B. J. and Lampe, K. H., eds). Springer, Bonn.

Gese, E.M. and Ruff, R.L. (1997). Scent-marking by coyotes, *Canis latrans*: the influence of social and ecological factors. *Anim. Behav*. 54: 1155−1166.

Gessesse Dessie (2007). *Forest Decline in South Central Ethiopia: Extent, History and Process*. PhD Dissertation, Stockholm University, Stockholm.

Gessesse Dessie and Kinuland, P. (2008). Khat expansion and forest decline in Wondo Genet, Ethiopia. *Geograph. Annal*. **90**: 187−203.

Gessesse Dessie and Kleman, J. (2007). Pattern and magnitude of deforestation in the south central Rift Valley region of Ethiopia. *Mount. Res. Develop*. **27**: 162–168.

Goddard, J. (1967). Home range, behavior and recruitment rates of two black rhinoceros populations. *E. Afr. Wildl. J.* **5**: 133−150.

Gorman, M.L. and Mills, M.G. (1984). Scent marking strategies in hyenas (Mammalia). *J. Zool*. **202**: 535−547.

Gorman, M. and Trowbridge, B. (1989). The Role of Odor in the Social Lives of Carnivores. **In**: *Carnivore Behavior, Ecology and Evolution*, pp. 57−88, (Gittleman, J., ed.). Cornell University Press, New York.

Gosling, L. M. **(**1982). A reassessment of the function of scent marking in territories. *Zeitschrift für Tierpsychology* **60:** 89−118.

Grossman, R.B. and Reinsch, T.G. (2002). Bulk Density and Linear Extensibility. **In**: *Methods of Soil Analysis, Soil Science Society of America*, pp. 201-228, (Dane, J.H., ed). Clarke Topp Inc., Madison.

Grubb, P., Jones, T.S., Davies, A.G., Edberg, E., Starin, E.D and Hill, J.E. (1998). *Mammals of Ghana, Sierra Leone and the Gambia*. The Tendrine Press, Cornwall.

Grzimek, B. (1990). *Mammals I – IV*: *Grzimek's Animal Life Encyclopedia*. McGraw-Hill Publishing Company, New York.

Halfpenny, J. (2008). *A Field Guide to Mammal Tracking in Western America*. California University Press, California.

Harris, S. and Yalden, D.W. (2008). *Mammals of the British Isles*. Mammal Society, London.

Hillman, J. C. (1992). *Review of the Traditional Civet Musk Extraction and a Proposal for Establishing a Model Civet Research Project in Ethiopia*. Ethiopian Wildlife Conservation Organization, Ministry of Agriculture, Addis Ababa.

Hirsch, B.T., Prange, S., Hauver,S.A. and Gehrt, S.D. (2014). Patterns of latrine use by raccoons (*Procyon lotor*) and implication for *Baylisascaris procyonis* transmission. *J. Wildl. Diseas*. **50**: 144−151.

Hodgkinson, C. (2009). *Tourists, gorillas and guns: Integrating Conservation and Development in the Central African Republic*. Ph.D. Dissertation, University College, London.

Hulsman, A., Dalerum, F., Swanepoel, L., Ganswindt, A., Sutherland, C. and Paris, M. (2010). Patterns of scat deposition by brown hyaenas *Hyaena brunnea* in a mountain savannah region of South Africa. *Wildl. Biol*. **16**: 445−451.

Hurst, J. L. **(**1987). The functions of urine marking in a free-living population of house mice, *Mus domesticus* Rutty. *An. Behav.* **35**: 1433–1442.

Hutchings, M.R., Service, K.M. and Harris, S. (2001). Defecation and urination patterns of badgers (*Meles meles*) at low density in south west England. *Acta Theriol*. **46**: 87–96.

IBC (2005). *Site Action Plan for the Conservation and Sustainable Use of the Awassa Lake's Biodiversity*. Institute of Biodiversity Conservation, Addis Ababa.

Jemal Mohammed (1999). The African civet (*Civttictis civetta*) and its farm prospect in Oromia Region. *A Paper Presented at the Workshop on the Preliminary Assessment of Traditional Civet Keeping in Oromia, Nekemet.* Agricultural and Development Bureau of Oromia, Addis Ababa.

Johnston, R. E., Munver, R. and Tung, C. (1995). Scent counter-marks: selective memory for the top scent by golden hamsters. *Anim. Behav.* **49**: 1435–1442.

Jones, M.L. (1982). Longevity of captive mammals. *Zool. Gard*. **52**: 113−128.

Jordan, N. R., Cherry, M. I. and Manser, M. B. (2007). Latrine distribution and patterns of use by wild meerkats: implications for territory and mate defense. *Anim. Behav.* **73**: 613–622.

Jordan, N.R. (2005). *Meerkat Latrines: Cooperation, Competition and Discrimination*. M.Sc. Thesis, University of Zürich, Zürich.

Jordano, P., Garcı´a, C., Godoy, J.A. and Garcı´a-Castan, J. L. (2007). Differential contribution of frugivores to complex seed dispersal patterns. *Proc. Nati. Acad. Sci*. **104**: 3278–3282.

Judge, J., Wilson, G.J., Macarthur, R., Delahay, R.J. and McDonald, R.A. (2013). Density and abundance of badger social groups in England and Wales in 2011–2013. Sceintic Reports 4: 3809 doi:10.1038/srep03809

Kamara, C.S. and Haque, I. (1987). *The Characteristics of Vertisols at ILCA's Research and Outreach Sites in Ethiopia.* Working Document No. B5. International Livestock Centre for Africa (ILCA), Addis Ababa.

Kindgon, J. (1997). *The Kingdon Field Guide to African Mammals*. Academic Press, London.

Kingdon, J. (1977). *East African Mammals: An Atlas of Evolution in Africa*. *Carnivores*. Academic Press, London.

Kock, D., Kunzel, T. and Rayaleh, H.A. (2000). The African civet, *Civettictis civetta* (Schreber, 1776), of Djibouti representing a new subspecies. *Senckenbergiana Biol.* **80**: 241–246.

Kruuk, H. and Hewson, R**. (**1978). Spacing and foraging of otters *(Lutra lutra)* in a marine habitat. *J. Zool.* **185:** 205−212.

Lamoot, I., Callebaut, J., Degezelle, T., Demeulenaere, E., Laquiere, J., Vandenberghe, C. and Hoffmann, M. (2004). Eliminative behavior of free-ranging horses: do they show latrine behavior or do they defecate where they graze? *Appl. Anim. Behav. Sci.* **86**: 105–121.

Lariviere, S. and Messeir, F. (2001). Space-use patterns by female striped skunks exposed to aggregations of simulation to duck nests. *Can. J. Zool.* **79**: 1604−1608.

Lekagul, B. and McNeely, J.A. (1977). *Mammals of Thailand*. Sahakarnbhat Co., Bangkok.

LFDP (1998). *Final Report. Lake Fisheries Development Project Working Paper*. Ministry of Agriculture, Addis Ababa.

Linklater, W.L., Mayer, K. And Swaisgood, R.R. (2013). Chemical signals of age, sex and identity in black rhinoceros. *Anim. Behav*. **85**: 671–677.

Lunt, N. (2011). *The Role of Small Antelope in Ecosystem Functioning in the Matobo Hills, Zimbabwe*. PhD Dissertation, Rhodes University, Grahamstown.

Macdonald, D. W. (1978). Observations on the behavior and ecology of the striped hyena, *Hyaena hyaena*, in Israel. *Israel J. Zool.* **27:** 189−198.

Macdonald, D. W. (1980). Patterns of scent marking with urine and faeces among carnivore communities. *Symp. Zool. Soc*. **45**: 107−139.

Makin, M.J., Kingham, T.J., Waddam, A.E., Birchall, C.J. and Tamene Teffera (1975). *Development Projects in the Southern Rift Valley of Ethiopia*, Land Resource Study No. 21. Land Resource Division, Ministry of Overseas Development, London.

Mallinson, J.J. (1973). The reproduction of the African civet *Viverra civetta* at Jersey Zoo. *Intern. Zoo Yearb.* **13**: 147−150.

Marcone, M.F. (2004). Composition and properties of Indonesian palm civet coffee (Kopi Luwak) and Ethiopian civet coffee. *Food Res. Intern*. **37**: 901−912.

Marino, J. and Sillero-Zubiri, C. (2013). *Canis simensis*. The IUCN Red List of Threatened Species. Version 2015.1. www.iucnredlist.org.

Mersha Gebrehiwot (2003). *Assessment of Natural Regeneration Diversity and Distribution of Forest Trees: A Case Study in Wondo-Wesha Catchement Awassa Watershed Southern Ethiopia.* M.Sc. Thesis, International Institute for Geo-Information Science and Earth Observation, Enschede.

Mesay Digafe (2008). *Species Composition, Diversity and Habitat Association of Birds in Wondo Genet, south Ethiopia*. MSc Thesis, Addis Ababa University, Addis Ababa.

Mesfin Admasu (1995). History of Civet Farming and Trade in Ethiopia. **In**: *Civet Farming, Musk Production and Trade Workshop*, pp. 72−78. Ethiopian Wildlife Conservation Organization. Addis Ababa.

Mills, M.G. (1990). *Kalahari Hyenas: Comparative Behavioral Ecology of Two Species*. Unwin Hyman, London.

Mudappa, D., Kumar, A. and Chellam, R. (2010). Diet and fruit choice of the brown palm civet *Paradoxurus jerdoni*, a viverrid endemic to the Western Ghats rainforest, India. *Trop. Conserv. Sci*. **3**: 282−300.

Müller, C A. and Manser, M. B. (2008). Scent-marking and intrasexual competition in a cooperative carnivore with low reproductive skew. *Ethology* **114**:174−185.

Murray, D.L., Roth, J.D., Ellsworth, E., Wiresing, A.J. and Steury, T.D. (2002). Estimating low-density snowshoe hare populations using fecal pellet counts. *Can. J. Zool*. **80**: 771−781.

Mykytowycz, R**. (**1970). The Role of Skin Glands in Mammalian Communication. **In**: *Communication by Chemical Signals. Advances in Chemoreception*, pp 327−360, (Johnson, W.J., Moulton, D. G. and Turk, A., eds). Appleton-Century- Crofts, New York.

Nakashim, Y. N. and Sukor, J. A. S. (2009). Importance of common palm civets (*Paradoxurus hermaphroditus*) as a long-distance disperser for large-seeded plants in degraded forests. *Tropics* **18**: 221–229.

Nelson, D.W. and Sommers, L.E. (1996). Total carbon, organic carbon, and organic matter. **In**: Methods of Soil Analysis, pp. 961-1010, (Page, A.L., ed). American Society of Agronomy Inc., Madison.

Nowak, R.M. (1999). *Walker's Mammals of the World*. Johns Hopkins University, Baltimore.

Nzouango, D. and Willcox, A.S. (2000). *Bushmeat Extraction Survey within the Banyangi and Mbo Tribes in the Southwest Province of Cameroon*. Wildlife Conservation Society Report, New York.

Ortiz, A., Dorantes, L., Gallndez, J. and Cárdenas, E. (2004). Effect of a novel oil extraction method on Avocado (*Persea americana*) pulp microstructure. *Plant Foods Hum. Nutr.* **59**: 11−14.

Ortolani, A. (1999). Spots, stripes, tail tips and dark eyes: predicting the function of carnivore color patterns using the comparative method. *Biol. J. Linn. Soc.* **67**: 433–476.

Palomares, F., Gaona, P., Ferreras, P. and Delibes, M. (1995). Positive effects on game species of top predators by controlling smaller predator populations: an example with lynx, mongooses, and rabbits. *Conserv. Biol.* **9**: 295−305.

Pankhurst, R. (1961). *An Economic History of Ethiopia: From Early Times to 1800*. Lalibela House, Addis Ababa.

Pendje, G. (1994). Fruit consumption and seed dispersal by the African civet *Civettictis civetta* in Mayombe, Zaire. *Revue D Ecologie-La Terre et la vie* **49**: 107–116.

Prange, S., Gehrt, S.D. and Wiggers, E.P. (2003). Demographic factors contributing to high raccoon densities in urban landscapes. *J. Wildl. Manag*. **67**: 324–333.

Prins, H. H. T. and Reitsma, J. M. (1989). Mammalian biomass in an African equatorial rain forest. *J. Anim. Ecol.* **58**: 851–861.

Pugh, M. (1998). *Civet Farming: An Ethiopian Investigation*. World Society for the Protection of Animals, London.

Putman, R.J. (1984). Facts from faeces. *Mammal Rev*. **14**: 79−97.

Quinn, J.H. and Whisson, D.A. (2005). The effect of anthropogenic food on the spatial behaviuor of small Indian mongooses (*Herpestes javanicus*) in a subtropical rainforest. *J. Zool. Lond.* **267**: 339−350.

Rabinowitz, A. R. (1991). Behavior and movement of sympatric civet species in Huai Kha Khaeng Wildlife Sanctuary, Thailand. *J. Zool*., *Lond.* **223**: 281–298.

Randall, R. M. (1979). Perineal gland marking by free-ranging African civets, *Civettictis civetta*. *J. Mammal*. **60**: 622–627.

Randall, R.M. (1977). *Aspects of the Ecology of the Civet Civettictis civetta (Schreber, 1778)*. M.Sc. Thesis, University of Pretoria, Pretoria.

Ray, J.C, Gaubert, P. and Hoffmann, M. (2008). *Civettictis civetta*. **In**: *IUCN 2013. IUCN Red List of Threatened Species.* Version 2013.2, Gland.

Ray, J.C. (1995*). Civettictis civetta*. *Mammal. Spec.* **488**: 1–7.

Ray, J.C. and Sunquist, J.T. (2001). *Forest Carnivore and the African Bushmeat Trade*. Bushmeat Crisis Task Force, Silver Spring, Maryland.

Ray, J.C., Hunter, L. and Zigouris, J. (2005). *Setting Conservation and Research Priorities for Larger African Carnivores*. WCS Working Paper No. 24. Wildlife Conservation Society, New York.

Richardson, P. (1993). The function of scent marking in territories: a resurrection of the intimidation hypothesis. *Trans. R. Soc. S. Afr.* **48**: 195−206.

Rosevear, D.R. (1974). *The Carnivores of West Africa*. British Museum of Natural History, London.

Rowe-Rowe, D.T. (1978). The small carnivores of Natal. *Lammergeyer* **23**: 1–48.

Rowe-Rowe, D.T. (1992). *The Carnivores of Natal*. Natal Parks Board, Pietermaritzburg.

Russo, S. E., Portnoy, S. and Augspurger, C. K. (2006). Incorporating animal behavior into seed dispersal models: Implications for seed shadows. *Ecology* **87**: 3160–3174.

Sandell, M. (1989). The mating tactics and spacing patterns of solitary carnivores. **In**: *Carnivore Behavior, Ecology and Evolution*, pp. 164−182, (Gittleman, J. C., ed). Chapman and Hall, London.

Schreiber, A., Wirth, R., Riffel, M. and Van Rompaey, H. (1989). *Weasels, Civets, Mongooses and their Relatives. An Action Plan for the Conservation of Mustelids and Viverrids*. IUCN, Gland.

Schwartz, M.K., Pilgrim, K.L. and McKelvey, K.S. (2007). DNA markers for identifying individual snowshoe hares using field collected pellets. *North West Sci*. **81**: 316–322.

Seyoum Mengistou and Fernando, C.H. (1991). Seasonality and abundance of some dominant crustacean zooplankton in Lake Awassa, a tropical rift valley lake in Ethiopia. *Hydrobiologia* **226:**137–152.

Sharma, G. P., Raghubanshi, A. S and Singh, J. S. (2005). Lantana invasion: an overview. *Weed Biol. Manage.* **5**: 157−167.

Shehzda, W., Riaz, T., Nawaz, M.A., Miquel, C., Poillot, C., Shah, S.A., Pompanon, F., Coissac, E. and Taberlet, P. (2012). Carnivore diet analysis based on next-generation sequencing: application to the leopard cat (*Prionailurus bengalensis*) in Pakistan. *Mol. Ecol*. **21**: 1951–1965.

Skinner, J.D. and Chimimba, C.T. (2005). *The Mammals of the Southern African Sub-region*. Cambridge University Press, Cambridge.

Skinners, J. D. and Smithers, R. H. (1990). *The Mammals of the South African Sub-region*. University of Pretoria, Pretoria.

Smithers, R. H. and Wilson, V. J. (1979). Checklist and atlas of the mammals of Zimbabwe Rhodesia. *Nat. Mus.Monu. Rhodesia* **9**:1–47.

Solberg, K.H., Bellemain, E., Drageset, O., Taberlet, P. and Swenson, J.E. (2005). An evaluation of field and non-invasive genetic methods to estimate brown bear (*Ursus arctos*) population size. *Biol. Conserv*. **128**: 158–68.

Sreedevi, M. B. (2001). *A Study on Certain Aspects of Breeding and Behavior of the Small Indian Civet, Viverricula indica* (Desmarest). PhD Dissertation, University of Kerala, Thiruvananthpuram.

Stewart, P.D., Macdonald, D.W., Newman, C. and Tattersall, F.H. (2002). Behavioral mechanisms of information transmission and reception by badgers, *Meles meles*, at latrines. *Anim. Behav*. **63**: 999–1007.

Stiles, F.G. and Rosselli, L. (1993). Consumption of fruits of the Melastomataceae by birds - how diffuse is coevolution. *Vegetation* **108**: 57–73.

Stuart, C. and Stuart, T. (2000). *Field Guide to Larger Mammals of Africa*. Struik Publishers, Johannesburg.

Tadele Tolosa and Fekadu Regassa (2007). The husbandry, welfare and health of captive African civets (*Vivera civetta*) in western Ethiopia. *Anim. Welf.* **16**: 15–19.

Tadesse Habtamu (2014). *Ecological Studies of the African Civets (Civettictis civetta) in Coffee Forest Habitat, Limmu Seka District, and an Assesment of Captive Maintenance as a Viable Economic Sources*. Ph.D. Dissertation, Addis Ababa University, Addis Ababa.

Taylor, M. E. (1970). Locomotion in some east African viverrids. *J. Mammal*. **51**: 42–51.

Tesfay Teklay (2005). *Organic Inputs from Agroforestry Trees On-Farms for Improving Soil Quality and Crop Productivity in Ethiopia*. PhD Dissertation, Swedish University of Agricultural Sciences, Umeå.

Tesfaye Hundessa (1996). Utilization of wildlife in Ethiopia. *Walia* **17**: 3–10.

Teshale Woldeamanuel (2003). *Analysis of Subsistence Farmers Rationales in Switching to Commercial Agriculture: The Case of Small Farmers in Wondo Genet, South Ethiopia*. Msc Thesis, Wageningen University, Wageningen.

Tiessen, H. and Moir, J.O. (1993). Total Organic Carbon. **In**: *Soil Sampling and Methods of Analysis*, pp. 187−211, (Carter, M.E., Ed). Lewis Publishers.

Todd, N.B. (1967). The karyotypes and diploid numbers of the African civet (*Civettictis civetta*) and the African palm civet (*Nandinia binotata*) with remarks on satellite chromosomes and taxonomy of the Feloidea. *Carniv. Genet. Newsl*. **3**: 49−51.

Tudorancea, C., Fernando, C.H. and Paggi, J.C. (1988). Food and feeding ecology of *Oreochromis niloticus* (Linnaeus, 1758) juveniles in Lake Awassa (Ethiopia). *Arch. Hydrobiol. Suppl.* **79:**267−289.

USDA (1998). *Nutrient Database for Standard Reference, Avocados*. United States Development of Agriculture, New York.

van Schaik, C. P., Terborgh, J. W. and Wright, S. J. (1993). The phenology of tropical forests: adaptive significance and consequences for primary consumers. *Ann. Rev. Ecol. System.* **24**: 353─377.

Walker, E.P. (1968). *Mammals of the World*. Johns Hopkins Press, Baltimore.

Weigl, R. (2005*). Longevity of Mammals in Captivity; from the Living Collections of the World*. Kleine Senckenberg-Reihe, Stuttgart.

Weladji, R.B. and Tchamba, M.N. (2003). Conflict between people and protected areas within Benoue wildlife conservation area, North Cameroon. *Oryx* **37**: 72−79.

Wemmer, C. and Watling, D. (1986). Ecology and status of the Sulawesi palm civet *Macrogalidia musschenbroekii . Biol. Conserv.* **35**: 1─17.

Willott, S.J., Miller, A.J., Incoll, L.D. and Compton, S.G. (2000). The contribution of rabbits (*Oryctolagus cuniculus* L.) to soil fertility in semi-arid Spain. *Biol.Fertil. Soi.* **31**: 379−384.

Wondmagegne Daniel (2006). *Ecological Studies on African Civet (Civettictis civetta) in Jima, Ethiopia*. M.Sc. Thesis, Addis Ababa University, Addis Ababa.

Wondmagegne Daniel, Afework Bekele, Balakrishnan, M. and Gurja Belay (2011). Collection of African Civet *Civettictis civetta* perineal gland secretion from naturally scent-marked sites. *Small Carniv. Conserv*. **44**: 14−18.

Woodford, J.D. (1990). *Conservation and Utilization: The Status of Wildlife in Ethiopia*. Ethiopian Wildlife Conservation Organization, Addis Ababa.

Wozencraft, W. C. (2005). Order Carnivora. **In**: *Mammals Species of the World*, pp. 548−559, (Wilson, D. E., Reeder, D. M., eds). Johns Hopkins University Press, Baltimore.

Wozencraft, W.C (1984). *A Phylogenetic Reappraisal of the Viverridae and its Relationship to other Carnivora*. PhD Dissertation, University of Kansas, Lawrence.

WSPA (1999). *Civet Farming: An Ethiopian Investigation*. World Society for the Protection of Animals, London.

Xavier, F. (1994a). *A Study on Small Indian Civet (Viverricula indica) as a Suistanble Wildlife Resources*. PhD Dissertation, University of Kerela, Thirhvananthrium.

Xavier, F. (1994b). Civet cats- A sustainable wildlife resources. *Contem. Zool.* **1**: 177−182.

Yilma Delellegn (2000). *Sustainable Utilization of the African civet (Civettictis civetta) in Ethiopia*. 2nd Pan-African Symposium of the Sustainable Use of Natural Resources in Africa, Ouagadougou.

Yilma Delellegn (2003). Sustainable Utilization of the African Civet (*Civettictis civetta*) in Ethiopia. **In**: *Second Pan-African Symposium on the Sustainable Use of Natural Resources in Africa*, pp. 197−208, (Bihini, W., Musiti, W., eds). IUCN, Gland.

Zewdu Eshetu and Hogberg, P. (2000). Effect of land use on 15N natural abundance of soils in Ethiopian highlands. *Plant Soil* **222**: 109–117.

Zhou, Y. B., Zhang, J., Slade, E., Zhang, L., Palomares, F., Chen, J., Wang, X. and Zhang, S. (2008). Dietary shifts in relation to fruit availability among masked palm civets (*Paguma larvata*) in Central China. *J. Mammal*. **89**: 435−447.