JIMMA UNIVERSITY,
COLLEGE OF NATURAL SCIENCES,
DEPARTMENT OF BIOLOGY

BEHAVIORAL STUDIES OF CAPTIVE AFRICAN CIVET (*Civettictis civetta*), IN SEMI-WILD ENVIRONMENT, JIMMA, SOUTHWESTERN ETHIOPIA

By: **Wondimu Mekuria**

A THESIS SUBMITTED TO DEPARTMENT OF BIOLOGY, COLLAGE OF NATURAL SCIENCES, JIMMA UNIVERSITY, FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE DEGREE OF MASTER OF SCIENCE IN BIOLOGY (Ecological and Systematic Zoology)

February, 2020

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Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented in this or other university and all sources or materials used for this study have been acknowledged

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Signature_____

Name of institution: Jimma University

Date of submission _____

Thesis has been submitted for examination with my approval as university advisor.

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ACRONYMS

WSPA	World Society for the Protection of Animals
IUCN	International Union for Conservation of Nature
EWCO	Ethiopian Wildlife Conservation Organization
EWCA	Ethiopian Wildlife Conservation Authority
GB	Giga Bite
SD	Storage Device
PIR	Passive Infrared
JIT	Jimma Institute of Technology

ABSTRACT

The Behavioural study of captive African civet (Civettictis civetta) in semi-wild environment was aimed to record the behavioural profile of the captive civets to provide civet farmers with reliable information in order to modernize their stock. The study was conducted in the research centre of captive breeding of African civets located in the compound of JIT campus from December 2018 to August 2019. African civet is known for its production of civet musk used as a fixative in perfume industry. In Ethiopia, the activity of civet husbandry persists with several problems including absence of modernity in the practice and poor handling of the animal. All the nocturnal behavioural patterns of captive civets were recorded by sensor camera traps and by direct observations at the night using moon light. Scent marking objects preference of captive African civets in the semi-wild enclosure was studied by using 40 poles with various parameters such as length, circumference, texture, angle of orientation. Captivity, where a number of civets existed together highly influenced the wild behaviour of the animals. Captive civets were developed social behaviour to some degree, and familiarity to human visitors and caregivers. The investigation of preference of scent mark objects by captive Africa civets showed that high level of scent marks were obtained on Psidium guajava (21.4%) which is extra smooth in texture, whereas the roughest plant Mystenus arbutifolia (5.5%) was the least marked plant species. In the outdoor enclosure, most of the scent marked objects were densely distributed along pathways. Captive breeding is strongly recommendable to minimize the welfare problems of civets in the civiculture practice. Captive bred individuals would be familiar in captivity and are free from behavioural stress compared to those trapped from the wild.

Key words: *African civet, captivity, civetry, musk, perineal gland secretion, scent marking*

1. INTRODUCTION

1.1 Background

Ethiopia is a biodiversity rich country. It is home of more than 300 species of mammals. There are 31 carnivore species which form 11% of the mammalian species in the country (Bekele and Yalden, 2013). African civet (*Civettictis civetta* Schreber, 1776*)* is one of these mammalian species categorized under family Viverridae that consists of 35 species of small to medium sized mammals (Nowak, 1999). Family Viverridae 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 is the only species of the genus *Civettictis*, which is the largest representative of the African viverrids (Kingdon, 1997).

The African civet is a member of Viverridae native to sub-Saharan Africa. It is distributed along a wide geographical range in Africa, from west to east-cost of Africa excluding the northern and more southern drier areas (Ray, 1995; Kock *et al*., 2000). In their ranges, they inhabit forest, savanna, forest edges, dry areas along water course, farmlands, human settlements and in urban areas (Ray *et al*., 2008; Mulu, 2015). No clear evidence of population dynamics is available to visualize the population trend of this species. They are categorized as "Least Concern" by IUCN (Ray *et al*., 2008) and some survey estimated that they are locally fairly abundant (Habtamu, 2014).

The African civet is a sturdily built, relatively long-legged animal which shares the affinities of a dog, cat and a genet at the same time (Kingdon, 1997; R-Zu-2-U, 2000). All its feet have five non-retractile claws. The hind legs of the civet are taller and more powerful than the forelegs (Pugh, 1998) and their tail is bushy, banded and half their total length. The coat varies from region to region but is generally buffy to dark to yellowish-grey (Estes, 1991). Its face is distinctive with black masks on each side of the face and the lips are white.

African civets are omnivorous and opportunistic foragers and feed on a wide variety of food items like fruits, berries, reptiles, rodents, birds eggs, diversity of invertebrates and decaying carrions (Tadele and Fikadu, 2007; Habtamu *et al*., 2017). Kingdon (1977) described these

animals to be unspecialized in any way including dietary habits and morphology. They eat almost anything and are able to live where cover is available.

African civet is predominantly nocturnal, but is occasionally seen in the morning or afternoon on overcast days (Kingdon, 1977; Randall' 1977). The peak of activity can occur just before and shortly following sunrise (Randall' 1977). There is an increased tendency for both sexes to move around when sexually active (Ewer, 1973). Nests of *C. civetta* consists of holes made by other animals or cavities under tangled roots and are readily vacated if the animal is distributed (Kingdon, 1977). African civets are solitary animals, except during the breeding period, when they may form groups of two or more individuals for a short period of time. They use olfactory signals as a major means of communication between conspecifics (Ray, 1995; Tsegaye *et al*., 2008a).

One characteristic, which has made African civet peculiar and economically important is its ability to produce a secretion (musk) from its perineal glands. 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 (Kingdon, 1977). 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 territory marking, sexual attraction, defense behaviors and warning. The civetry also provide information regarding diet composition of civets and its seasonality, scent communication, population size and their potential for seed dispersal (Solberg *et al*., 2005; Russo *et al*., 2006; Tsegaye *et al*., 2008a, b; Habtamu *et al.*, 2017).

Civiculture plays a significant role in the economic history of Ethiopia, especially in the 18th and 19th century. Musk extracted from the civet was exported to various countries, and even it served as a currency in the past (Woodford, 1990). It is used in perfume industry, traditional medicine and to flavor tobacco (Xavier, 1994a, b). Musk is usually light yellowish in colour and has a consistency of thick grease at collection but hardens and turns to dark-brown or black with ageing (Anonis, 1997). Currently, civet farming is practiced as a means of income in many parts of Ethiopia (EWCO, 2013; Habtamu and Bekele, 2014). 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 (Delellegn, 2003). In addition, the farming practice

is blamed for animal welfare reasons including extremely backward animal handling and lack of captive bred and domesticated civets (WSPA, 2000)

Despite the long husbandry practice and the vital role of musk in supporting livelihoods of farmers, no tradition of breeding civets in captivity, instead male civets are selectively trapped from wild to stock farms. This practice has great impact on the wellbeing of the animal and the genetic quality of civets in wild.

As a base for captive breeding, all behavioural attributes experienced by captive civets must be recorded and understood. Knowledge of civet behaviour under captive condition will help in understanding why and when do they prefer certain behaviour, which in turn have greater significance for captive breeding and domestication procedures (Ewer and Wemmer, 1974). Thus, the aim of this study was to examine all behavioral aspects of captive African civets that were trapped and kept in the semi-natural enclosure for captive breeding experiment.

1.2 Statement of the problem

Activity of civet husbandry in Ethiopia is entirely traditional and has shown no change for over a century. The reasons for the primitive farming tradition is largely because of the people in the business are highly secretive and not ready for improvements in farming and husbandry practices (Habtamu, 2014). The sector is monopolized by some groups in the society and handed down to descendants that allows no room for alien participation and hence little input of knowledge for its modernity. As a result, the sector persist with several problems including unsafe trapping, poor caging, inadequate nutrition, poor housing and handling, parasitic load, insufficient restraint and musk extraction facilities (Tadele and Fikadu, 2007). With some current initiative however, most problems regarding the husbandry (including safe trapping, suitable caging, diet, safe musk extraction, medication) are addressed (Habtamu and Bekele, 2014). But still farmers selectively trap male civets from the wild to stock their farm.

Captive breeding is expected to play an important role in enhancing musk productivity both in quantity and quality. It also reduces the pressure on the wild species. Little is known about the African civet behavior both in captivity and in wild, since it is an extremely secretive species, and is not seen in daylight. Therefore, the present study entirely focused on recording behavioural profiles exhibited by captive African civets.

1.3. Objectives

1.3.1 General objective

The general objective of this study was to record behavioral aspects of captive African civets under semi-natural setting in Jimma area, Southwest Ethiopia.

1.3.2 Specific objectives

The specific objectives of this study are;

- To record the behaviour of newly recruited civets (in cages and enclosure) and reaction for visitors.
- To investigate social interactions among captive African civets.
- To identify the preference of scent marking objects by captive civets.
- To investigate the feeding behaviour of captive African civets.

1.4 Significance of the study

The practice of keeping civets in captivity to extract their musk is a long rooted cultural component of the society that goes back many centuries in Ethiopia. It plays important role in supporting the livelihood of many rural families of the country. However, the practice is traditional and no tradition of breeding civets in captivity. Captive breeding of civets play important role in maximizing the productivity of musk both in quantity and quality. It also reduces the welfare problems and pressure on wild species. Careful tracking and recording behaviour of civets in captive environment has a significant contribution and serve as a base for captive breeding experiences.

Therefore recording the behavioural profile of the animal in captivity is crucial for civet farmers by providing them with reliable information in order to modernize their stock. Such behavioural study of captive civets can also generate concepts that are applicable for the wild ones, so make conservation easier.

2. LITERATURE REVIEW

2.1 Taxonomy of the African civets

African civet is classified under the Class Mammalia, Order Carnivora, Family Viverridae Subfamily Viverrinae and genus Civettictis. 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 Genera 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. Hemigalinae and Paradoxurinae (the Asian palm civets) are confined to South and South-east Asia, whereas Viverrinae is distributed across Asia, Africa and part of Europe. The Asian linsang (Prionodontinae) is distributed across Asia.

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. The African civet is named as *Civettictis civetta* Schreber, 1776, and there are six distinct subspecies. These are *Civettictis civetta australis, Civettictis civetta civetta, Civettictis civetta congica, Civettictis civetta pauli, Civettictis civetta schwarzi and Civettictis civetta volkmanni (*Ray, 1995; Kock, *et al.*, 2000*).*

2.2 Physical features of African civets

The African Civet (*Civettictis civetta*) shares the affinities of a dog, cat and a genet at the same time (Kingdon, 1997; R-Zu-2-U, 2000). All its feet have five non-retractile claws (Estes, 1991). It has a short and strong neck, a pointed muzzle, small eyes, and small rounded ears (Wozencraft, 1984; Skinner and Smithers, 1990). It is easily recognizable by its disproportionately large hindquarters, low-headed stance and erective dorsal crest. Hindquarters are higher and more powerful because the hind legs are larger and longer than forelegs (Ray, 1995). The tail is coarse-haired with long bristles. Along the spines from the neck to the tail, a line of shaggy black hairs form an erective crest giving the animal a large appearance (Kingdon, 1997). A light

colored stripe is situated along the contour alternatively with black and white and is not visible until the animal erects the spinal crest, allowing it to assume a larger and more threatening posture (Estes, 1991; Ray, 1995). African civet is an omnivorous mammal**.** The broader and flatter molars of *Civettictis* may be secondary adaptations for a more crushing and grinding of food (William, 2003).

The perineal glands are located near scrotum in males and between the anus and the vulva in females. It is what this civet has historically been most often harvested for. This gland secretes a white or yellow waxy substance called civet (musk), which is used by civets for marking territory and by humans as a perfume base. Perineal glands are found in both male and female civets, however, the glands are bigger in males, which can produce a stronger secretion (Ray, 1995).

2.3 Ecology of African civet

2.3.1 Habitats

The African civets are terrestrial, lives in forest and in open habitats with thickest cover for day time (Kingdon, 1997). They also inhabit cultivated land, savanna, forest edges, dry areas along water course, farmlands, human settlements and in urban areas (Ray *et al*., 2008; Melese *et al*., 2014) and regularly visit homesteads to being attracted by human litter (Kingdon, 1997; Habtamu and Bekele, 2014). Such habitats often favor rodents and arthropods or provide alternate food sources such as fruits (Ray *et al*., 2005).

2.3.2 Geographical distribution

African civets occur in sub-Saharan Africa from 15ºN to 24ºS latitude. The east-west range extends from Senegal to the east coast. They are present on the islands of Zanzibar, but absent from Madagascar. In Somalia, they occur only in the extreme south (Skinner and Smithers, 1990).They are absent in South Africa (except Transvaal) and most part of Namibia and Eritrea and drier parts of the horn (Kingdon, 1997). In Ethiopia, African civets are quite abundant species recorded from altitudes ranging between 550 m a.s.l (Alatish National Park) (Habtamu and Bekele, 2005) and over 3400 (Bale Mountains National park) (Ermias *et al.,* 2004). Yalden *et al*. (1980) reviewed the site of occurrence by different observers ranging from 1790 and 1976, encompassing the whole land areas of the country. The species is absent in the north and

southeastern drier areas of the country, however, highly abundant in the South and southwestern montane forest (Yalden *et al*., 1980; Habtamu and Bekele, 2014). The abundance of civets in this part of the country might be the reason for persistence of civiculture in some Southwestern zones of Oromia (Jimma, Illu-Abbabora and all Zones of Wollega) (Wakjira, 2005; Habtamu and Bekele, 2014).

2.3.3 Feeding Behaviour

The African civet, anatomically and phylogenetically is a carnivore, but functionally omnivore (Habtamu and Bekele, 2014). Its omnivorous diet includes rodents, birds, bird eggs, reptiles, arthropods, invertebrates and carrions, fruits, and other plant parts (Gittleman, 1996; Bekele, 2017; Habtamu *et al*., 2017). These authors revealed that African civet is able to eat items that are usually poisonous or distasteful to most mammals, including the fruits of *Stychnos* (bitter tasting plant), poisonous invertebrates and snakes and highly decayed carrion. Civets also raid crops and domestic animals such as poultry (Ray and Sunquist, 2001; Habtamu *et al*., 2017).

2.3.4 Defecation Behaviour

Civets do not bury their feces, but they accumulate it in open places known as civetry. Civetry sites are not only used as a site of defecation; they may also have roles in communication, territoriality, warning and defense behaviors (Jordan *et al*., 2007). 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 (Tsegaye *et al*., 2008b), scent communication (Espírito-Santo *et al*., 2007; Tsegaye *et al*., 2008a; Habtamu *et al*., 2017), population size (Solberg *et al*., 2005), mechanism of seed dispersal and evolution of plant community (Fiorelli *et al*., 2013). They establish their latrines near pathways in open and relatively dry soil. Latrines may provide a rich microhabitat for seedlings, thus the African civets act as seed dispersal agent (Pendje, 1994). Individuals visit more than one latrine sites and will be repeatedly used by more individuals in recognized group (Habtamu and Bekele, 2014). During defecation, perineal glandular secretion is added to the faeces, making it to have a long-lasting odor. African civets use each civetry for a long period (Daniel, 2006; Birhanu, 2007; Tsegaye *et al*., 2008b).

2.3.5 Breeding behavior

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 and 28 years in captivity (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).

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. 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.

2.4 Practice of civiculture in Ethiopia

Ethiopia is a center of origin of civiculture and has a long history of musk production for traditional and commercial purposes long before the time of the legendary Queen of Sheba (1013-982 B.C) (EWCO, 1999; Mohammed, 1999; WSPA, 2000). The tradition was first originated in the northern part of the country, later traders introduced into the south, particularly to Jimma and from there the practice spread to the southwestern part of the country (EWCA, 2013).

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). 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 (Habtamu, 2014). Main activities in civet farming include feeding, cage cleaning, disease treatment and musk collection. The only experience required for civet farming is knowledge of handling animals (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 (EWCO, 1999). 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 (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.

2.5 The economic importance of African civet

One characteristic, which has made African civet peculiar and economically important to others, is its ability to produce a secretion from its perineal glands (Kingdon, 1977). These glands are located below the tail and by keeping the animals in captivity it is possible to extract the secretion regularly. The secretion from this animal is known as civet (musk) and the refined compound “civetone” was first identified in the 1920s (Anonis, 1997). Recently the detail composition of perineal gland secretion was investigated in 2016 in coffee dominated areas of Jimma, Limmu district (Habtamu *et al*., 2016). Man, for several hundred years, has been able to keep civets in captivity and collect the plentiful secretion from this animal’s glands for fixing flower-based perfumes. Although synthetic musk, crystalline aroma chemicals and viscous

essential oils are a source of comparatively good fixatives, high quality perfume producers still prefer the use of civetone (Williams and Curtis, 1994). Musk is usually adulterated by substances including potatoes, brilliantine, butter, bananas, beans, mango, flour and honey (Anonis, 1997). The musk collected from Civets is shipped to perfume producing countries, and forms an important export commodity.

Ethiopia has been producing nearly 90% of the world's civet musk (Mohammed, 1999) and recorded history shows that other countries which used to produce the musk were Ghana and Zanzibar. Hillman (1992) also mentions Niger and Senegal as countries, which produce small quantities. Civet cat rearing is a fairly profitable business and serves as means of livelihood for farmers (Wakjira, 2005; Tadele and Fikadu, 2007) and is economically important activity (Kingdon, 1977).

3. METHODOLOGY

3.1 Study area

3.1.1 Description of the study area

The study was conducted in the outskirt of Jimma town in campus of Jimma Institute of Technology (Kitto Furdisa). Jimma University is located in southwestern Ethiopia at 367km south-west of Addis Ababa. Jimma is found at an average altitude of 1700 - 2250 m asl (Habtamu, 2013). It lies in the climatic zone locally known as “Woyna Daga” (1,500 - 2,400m above sea level) which is considered ideal for agriculture as well as human settlement.

The project of Captive breeding of African civets was already established in Jimma Institute of Technology campus, Jimma University (Figure 1). This area is appropriate for the African civet breeding research for several reasons including the abundance of suitable civet habitats, access to food sources for supplemental feeding, access to veterinary facility, more accessible for repeated visit for behavioral records. The present research was conducted on set up already established for Captive breeding research (Jointly established by researchers from Jimma and Addis Abeba Universities).

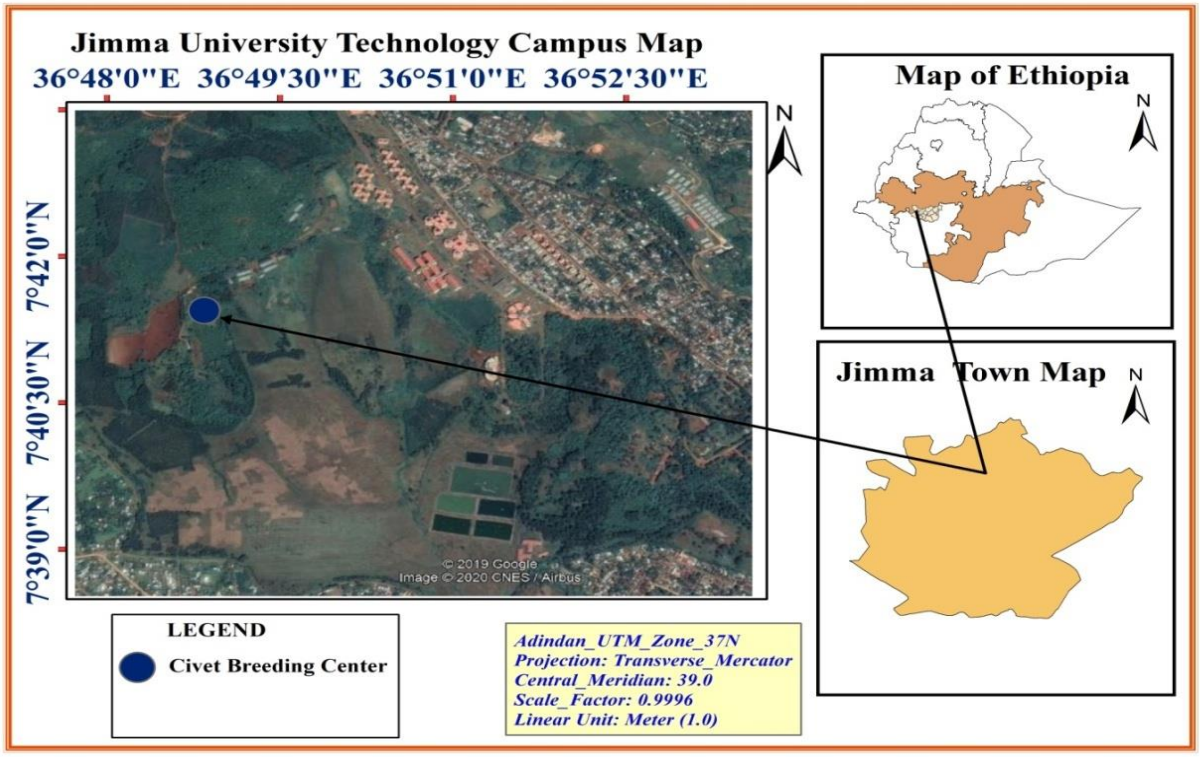

Figure 1. Map of the study area

3.1.2 Climatic condition

3.1.2.1 Temperature

According to data obtained from Ethiopian Meteorological Agency, Western Oromia branch, Jimma town is characterized by moderate temperature with a mean annual maximum temperature of 27.8°C and a mean annual minimum temperature of 12.1°C. The highest mean monthly temperature was recorded in February and March (30.1 and 30.2^{o}C respectively), while the coldest temperature was recorded in January (6.8^{o}C) (EMA, 2019) (Fig. 2).

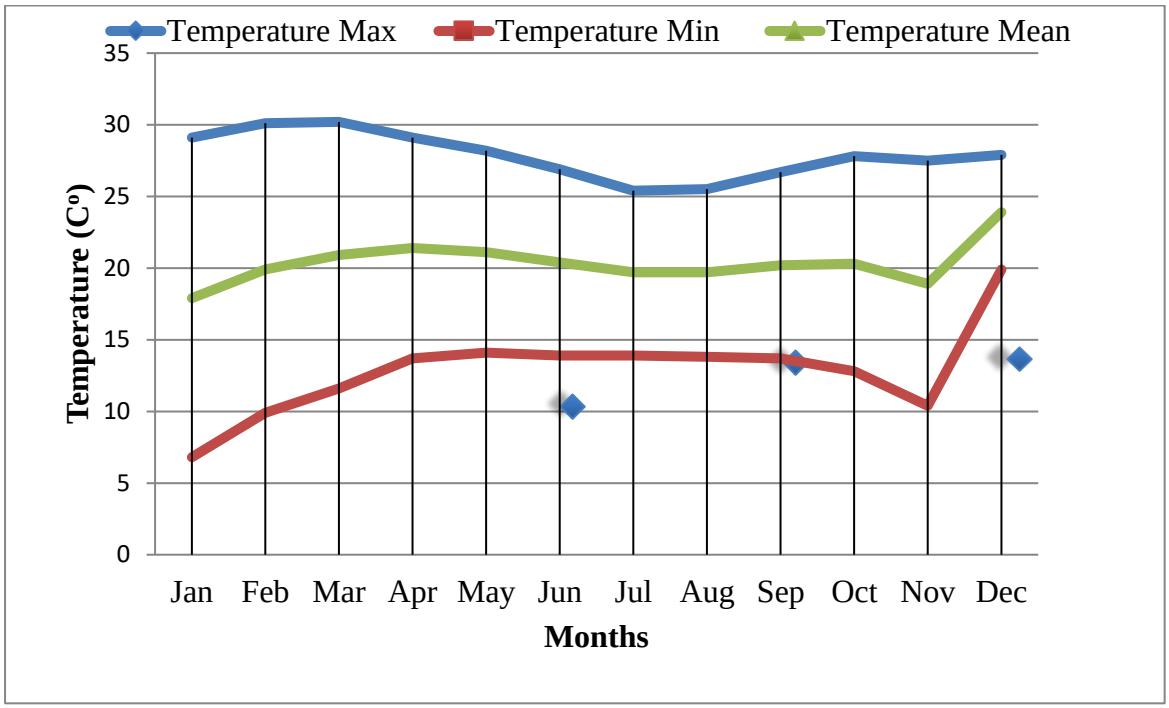

Figure 2. Mean monthly temperature of Jimma town (2014 – 2018) (EMA, 2019).

3.1.2.2 Rainfall

The five years rainfall data (2014 - 2018) revealed that the study area receives an average rainfall of 1608.7mm ranging between 1429.4 and 1935 mm. The area receives the highest rainfall during the wet season in June, July and August, and the lowest rainfall during the dry season (December to February) (Figure 3).

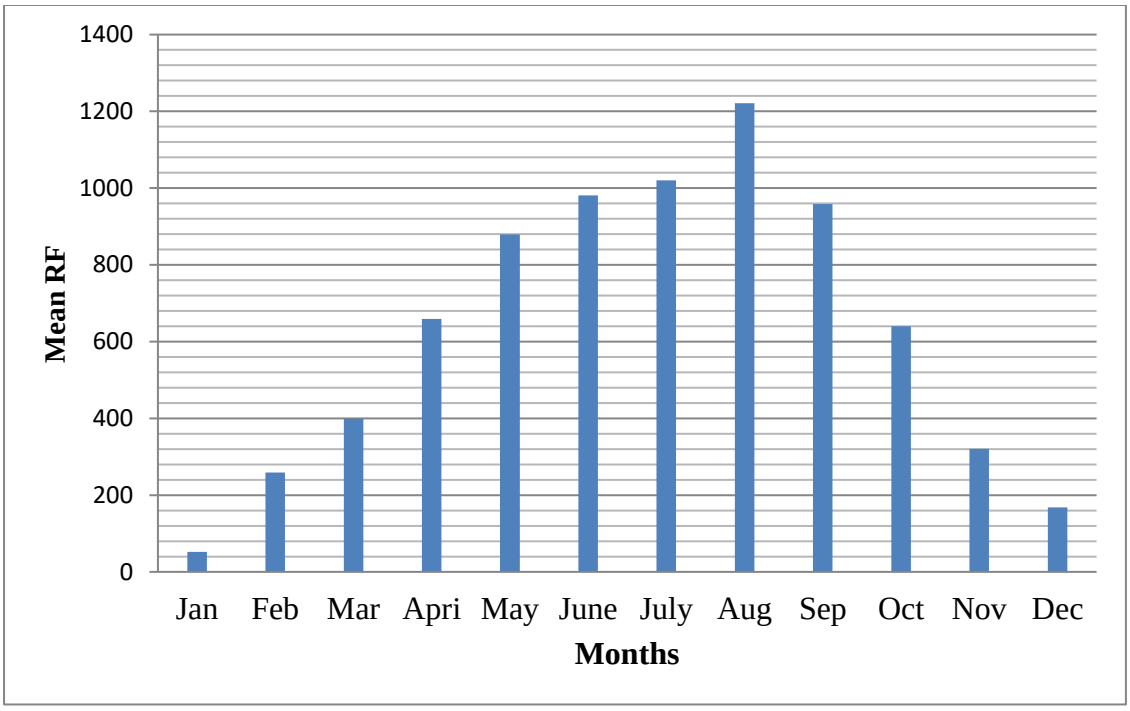

Figure 3. Mean monthly rainfall of Jimma town (2014 – 2018) (EMA, 2019).

3.2 Study design

The African civet breeding center was established on 75m x 75m outdoor enclosure in wilderness area with dense natural vegetation. The area was fenced with wildlife wire mesh 2m high and corrugated metal sheet at the end of the wire mesh to prevent civets from jumping out. Captive civet behavioural record was started with a total of 10 civets (three males and seven females) all trapped arbitrarily from wild. Before newly recruited civets were released in the outdoor enclosure, they were kept in quarantine for a month or two to confirm whether they were free from any communicable diseases. During quarantine, civets were treated for endo and ectoparasite (Habtamu *et al*., 2017), and kept in individual cage and feed individually in feeding bowl. Captive civets were fed on the food recipe formulated as a regular civet diet (Habtamu, 2014). All nocturnal activities of captive civets were recorded by using sensor cameras, and also by direct observation of the animals from the venture purposely prepared. Scent mark objects preference of civets was studied by recording markings from purposely set poles and objects already existed in the enclosure.

3.3 Materials

To conduct the behavioural study of captive African civet, materials such as data sheets, tape measures, digital cameras, note books, camera traps, night vision binoculars and personal computer were used.

3.4 Data Collection

3.4.1 Behavioural data collection by direct observation

Behavioral data were collected for eight (8) consecutive months from December 2018 to July, 2019. Every week, three days of observations were made regularly throughout the study period. During this time, all kinds of interactions, feeding, latrine site use and scent marking experienced by captive civets were closely observed and recorded. Observations were made during periods of no disturbance, by taking care that the observer's presence did not alter the usual behaviour of the animal. Observations of every nocturnal behavioral activity of civets were made at night (7:30 - 10:30 PM) by using night vision binocular. The unit observation time was three hours, and a total of 288 hours of night observations were made.

3.4.2 Behavioural data collection by camera traps

Camera trap studies have often yielded key behavioural insights that may otherwise have remained unknown, many of which could be important to conservation processes (Ford *et al*., 2009).

During the present study, behavioural data for nocturnal and cryptic activities of captive civets were collected using digital camera traps (Bushnell Trophy Cam. Model #S.119537C, 2013, USA). All behavioural profiles of captive African civets including feeding and defecation behaviour, and social interactions were recorded by sensor cameras. The camera is auto-triggered by motion detected by a high sensitive passive infra red (PIR) motion sensor, and then takes high quality pictures or video clips. They were programmed to capture motion at night, to record videos for 30s with 1s interval between successive capture. For this purpose seven camera traps with 16 GB SD were set in different locations (civetry sites, walking path, communal and individual feeding sites) within the semi-wild enclosure. The cameras were fixed at 30–50 cm above the ground to get clear images of the animals (Jansen *et al.,* 2014) (Figure 4). They were

attached to trees, which had at least 15 cm breast height diameter (Srbek-Araujo & Chiarello, 2005) to allow a tight fit, and prevent dislocation, when individual animals were examining the particular camera trap unit at close distance. The recorded videos were taken every day and categorized according to the behaviour displayed by the animals. All behavioural activities of captive civets including feeding behaviour (communal or individual), interactions (social or agonistic) and scent marking were studied using camera traps. The recorded data were organized under each month of study to determine the progress of interactions among captive civets.

Figure 4. Camera trap fixed to record nocturnal activities of civets (Photo by Wondimu M. 2019)

3.4.3 Scent marking behaviour

To identify the preference of scent marking objects, eight plant species commonly found in the area were used. These plants were *Eucalyptus camaldulensis, Clausena anisata, Croton*

macrostachyus, Vernonia auriculifera, Grevillea robusta, Mystenus arbutifolia, Sesbania sesban and *Psidium guajava*. A total of 40 scent marking poles (five poles from each species) with various parameters (length, thickness, texture, top end and angle) were fixed in various positions in the study area. Poles were fixed at different distance from civetry and walking way (<20cm, 20 - 30cm, 30- 40cm, 40 – 50cm and above 50cm).

The height of the marking sites on the signpost was measured to identify suitable height at which civets scent marked. The species of plants marked were identified. Distance from civetries and tracks were measured to analyze the distribution of scent marks in the outdoor enclosure. The scent marking secretion was removed from signposts; the date was recorded and observed for remarking to know the frequency of scent marking (Daniel, 2006). Similarly, markings on non-targeted objects such as rocks, herbs, grasses, fence and on the ground were also recorded to identify marking objects preferences.

3.5 Data analysis

Data generated by observation and from video records were analyzed qualitatively and quantitatively. Such data were organized and categorized under different activities (individual feeding, communal feeding, defecation, social interactions and scent markings).

The level of preference to scent mark on the objects was calculated using frequency of occurrence of each of the objects expressed as percentage. The height of each of the scent marks was measured from the ground. The mean height at which scent marks observed was calculated. The distance of scent marks around civetry sites and around the pathway were measured by a measuring tape (Daniel, 2006).

4. RESULTS AND DISCUSSION

4.1 Behavioural patterns of captive African civets

4.1.1 Behaviour in cages during quarantine

The present investigation confirmed that there were significant behavioural modifications among captive civets as behavioral patterns may fluctuate readily with environment and social context. All individuals of captive civets were expressed similar natural range of behaviors as they were captured from the wild, and exposed to the same conditions. The animals were kept in quarantine for a month to confirm their health status before releasing them to the outdoor enclosure. In quarantine, they displayed a number of unusual and tress full activities including attempts to hide themselves from visitors, repeated back and forth movement, circular face rubbing, repeated urination and defecation, stepping in the feeding bowels and spill soup (food) away, producing aggressive and fear sounds, trying to escape from cages. These activities in turn followed with physical damages (in few animals), losing the desire for food, and in some cases excessive sleeping was also observed. However, all these activities lasted only for the first 2 – 3 days. In the late days, they became calm, and habituated to the presence of the care givers and became familiarized with all the new situations. But the presence of unfamiliar visitors was detected very quickly and still sign of stress displayed.

4.1.2 Behaviour in the outdoor enclosure

The usual wild behavior might not displayed in captivity, as animals face changes in various environmental conditions. Changes in such factors lead to changes in behavioural patterns. Captivity, where a number of individual civets existed in a small confined area might greatly influence the behavioural patterns of the animals. The introduction of civets to the outdoor enclosure was accompanied with several unusual behavioural activities. The released civets run blindly to the nearby thick vegetation cover and hided in it. After 20 - 30 minutes rest time, they started to move actively in the enclosure in searching the way let them out. For the first 2 – 3 hours after release, repeated attempts to escape from the enclosure were observed, even during the day time when the animals are expected inactive. However, after several trials, they became calm and search for a dense vegetation cover where they hide themselves. But the trials to escape and restlessness were continued at night for the first four to five days. In the late

days, they were completely at rest during the day time. While sleeping (for few months after the study was commenced), each civet sleep independently, prefer thick vegetation and extremely cryptic and was very hard to locate their sleeping site. However, four months later, their sleeping sites were well predicted, more visible and civets observed sharing day time resting sites.

4.1.3 Social interactions among captive civets

As civets are highly territorial, first time exposure to other conspesifics in the enclosure was followed by various aggressive reactions. During the early period of this study (December to February), any kind of tolerance and social interactions (communal feeding, walking and sleeping in groups) among the captive civets were not observed completely. Each individual perform every activity independently. Aggressive reactions including chasing and fighting were common. In some cases, physical damages were observed on the body of some civets that might occur due to strong fight among them. Aggression and defensive threat were followed with physical changes like erection of the long hair of the dorsal crest. However, all such agonistic reactions were less observed during the late three months (May to July) (Table 1) as the animals showed some degree of tolerance (Figure 5). Activities like feeding in groups of two to three individuals and sleeping in the same space during day time were observed repeatedly. Repetitive exposure to one another might be gradually developed the social behaviour among them.

In some cases, one or two civets were observed wandering around the established trail during the morning up to 9:00 am. In such instance these civets continually move on the same trail on the distance fewer than 20m repeatedly move back and forth along the same established trail. During such activity observer stand still can watch this behaviour with distance between 2 – 5 meters and civets did not realize the presence of observer with this distance.

Table 1. Social behaviour of captive civets (direct observations and camera records)

Activities	Month								Total
	Dec	Jan	Feb.	Mar	Apr.	May	June	July	
	Number of observations								
Communal Feeding	0	0	1	5	6	7	10	9	**38**
Walking in group	0	0	2	6	4	6	9	9	**18**
Sleeping in group	0	0	0	2	3	3	4	6	**18**
Fighting	10	7	6	4	4	2	3	0	**36**
Chasing	7	7	4	6	3	2	1	2	**32**

Figure 5. Familiarity among captive civets

4.1.4 Civetry establishment

Captive civets under the present study established three permanent latrine sites (civetries) at different locations during the early period after they released to the outdoor enclosure. All the civetry sites were distributed along pathways in dense vegetation cover. However, two of the civetries were not persisted for longer period, only one of the civetries was used longer (Figure 6). Each individual used the same place each night to deposit its droppings and a large pile was accumulated.

Figure 6. The Common defecation site (civetry) established by captive civets

Captive civets always visited the civetry after feeding. Before defecation, they slowly move to defecation site, carefully inspect the area and sniff the previously deposited feces. While defecating, the animal stands with the back slightly arched and the tail held out horizontally or sloping slightly downwards (Figure 7). After defecation, they move quickly from the area and other visitors replaced.

Figure 7. Defecating civet at civetry site

4.1.5 Feeding behaviour

Captive civets were fed on the food recipe formulated as a regular civet diet. During the early period of this study, each captive civet feed individually and preferred to feed on their habituated bowel. After repeated bouts they also visited bowels of neighboring civets. In the late five months (March to July), communal feeding were common. There were a number of occasions when civets feed in groups of two or more individuals from the same bowel (Figure 8).

Figure 8. Communal feeding of captive civets

4.2. Scent marking behaviour of African civets

For solitary, cryptic and nocturnal species, chemical signals are used as a 'bulletin boards' that relay messages in the absence of the sender (Burger, 2005; Scordato and Drea, 2007). Scent marking is one of the major forms of communications among African civets. The present study revealed that captive civets marked any suitable objects available in the enclosure using their perineal gland secretion. Stems of various plant species, poles, rocks, fence and metallic objects were commonly marked by captive civets. Scent marking behaviour of captive civets was slightly different from the wild ones. As a number of individual civets confined in small space, large numbers of markings were observed at any corner of the enclosure. In such cases, scent-mark might have no role in territorial defense as many animals share the same small habitat.

4.2.1 Scent marking strategies

Two ways of scent markings were observed. An intermittent squatting (civets lower head stance seem to sniff the scent marked on the ground). If scent is detected, they rub their hind end against ground and over-marked it (Figure 9). In this marking strategy, the quantity of secretion

deposited on the ground was quite small; it probably involves depositing secretion from anal gland, not from perineal gland.

Figure 9. An intermittent squatting

The other strategy was scent marking sign posts. This involves tail lifting and gentile pressing against the objects (suitable upright stick, rock, edge of upright concrete walls or any other suitable objects) and side to side shaking of the pressed part to deposit as much musk as possible (Figure 10). All new objects in their vicinity were immediately marked.

Figure 10. Scent marking sign posts

4.2.2 Scent mark objects preference

During the present study period, a total of 155 scent marked objects were identified on poles prepared from various plant species with various parameters (plant species, bark texture, angle to the ground, pole circumference and pole length). Markings were observed on the stems of several plant species and other objects. However, the frequency of scent-mark varied from species to species. There was a high level of preference to mark on *Psidium guajava* (21.94%), and this followed by *Eucalyptus camaldulensis* (18.06%), whereas the minimum markings were observed on *Mystenus arbutifolia* (5.16%) (Table 2).

Table 2. Scent marking preferences of captive African civets on targeted plant species

No	Plant species	Texture	Total scent mark	% of scent mark	Status
1	*Psidium guajava*	Extra Smooth	34	21.94	1
2	*Eucalyptus camaldulensis*	Semi-rough	28	18.06	2
3	*Croton macrostachyus*	Smooth	22	14.19	3
4	*Clausena anisata*	Slightly smooth	22	14.19	3
5	*Grevillea robusta*	Rough	15	9.68	5
6	*Sesbania sesban*	Slightly smooth	14	9.03	6
7	*Vernonia auriculifera*	Semi-rough	12	7.74	7
8	*Mystenus arbutifolia*	Extra rough	8	5.16	8
	Total		**155**	100	

Scent markings by captive civets were also recorded on various non-targeted objects like rocks, herbs, grass, fence and even on the ground. The highest markings were recorded on rocks (30.9%), which were semi-smooth in texture. Poles of fence were the second frequently marked (23.5%), while the least markings were found on the ground (11.8%) which was semi-rough in texture (Table 3).

Table 3. Scent marking preferences of captive African civets on non-targeted objects

No	Marked objects	Texture	Total scent mark	% of scent mark
1	Rocks	Semi smooth	21	30.9
2	Herbs	Smooth	10	14.7
3	Grasses	Smooth	13	19.1
4	Fence poles	Semi smooth	16	23.5
5	Ground	Semi rough	8	11.8
	Total		**68**	

Findings from adjacent kebeles of Jimma town by Mulu *et al*., (2011) indicated that *Eucalyptus globules* was frequently marked by civets (62.5%), and only 7.3 % was observed on *Psidium guajava*. 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.

Scent mark object preference can also be associated with the bark texture of plant species used as samples. The high frequency of marking on *P. guajava* might be due to its extra smooth texture, and *M. arbutifolia* was marked least as the extra rough texture of the stem is unsuitable for civets to scent mark. Earlier findings by (Mulu, 2006) also reported that African civets prefer to mark objects with smooth surfaces more often than those with rough surfaces. It was also suggested by Randall (1979) that the objects unsuitable for civets to scent mark were those trees with thick and thorny branches at the base. Preference of smooth surfaced objects may avoid injury to glandular areas whilst they press and rub the sign-posts during scent-marking, even if few hard rough-barked stems were found marked during the present observations.

4.2.3 Marking height and pole tip conditions

Scent markings by captive civets on targeted poles were observed at various heights from the ground. The heights seen ranged from 28 to 31 cm, with the mean height 29.8 cm. This indicated most of the civets under the study were under adult and sub-adult in age group. Tsegaye *et al.* (2008a) indicated that the height at which the scent-marks are laid denotes mostly the height of the posterior quarters of the animals, which might also give an indication about the approximate age of the individuals. Out of the total 155 scent marked objects, 55.5% sign-posts were marked at 30cm from the ground. The second frequently marked height was 29cm on which 24.5% markings were recorded. However, the height at which the least markings were recorded was 28cm (5.8%), and no marks were observed above 31 and below 28cm (Table 4). In few sign-posts, scent marks were observed at two different heights on the same object. This might indicate more than one individuals categorized under different age groups used the same sign-post to scent mark.

The upper tip condition of targeted poles also exhibited variation in the frequency of scent-markings. Poles with complete round top end were repeatedly marked (82.6%), while fully sharpened objects were least preferred (7.1%) (Table 4). Pole orientations also matter the

frequency of markings. Out of the total 155 markings, 91.6% were found on poles with vertical orientation, and the rest 8.4% were recorded on poles with angles less than 90º from the ground (Table 4).

Table 4. Rod height, angle and upper tip condition preference by African civets

Plant species	Height at which scent is marked						Upper tip condition			Angle of the rod		
	27cm	28cm	29cm	30cm	31cm	>31cm	01	02	03	45º	60º	90º
	Number of observations											
E. camaldulensis	0	1	4	18	5	0	23	3	2	0	2	26
C. anisata	0	2	7	10	3	0	17	2	3	0	0	22
C. macrostachyus	0	2	5	13	2	0	21	1	0	0	0	22
S. sesban	0	1	5	6	2	0	11	2	1	1	1	12
P. guajava	0	3	7	21	3	0	28	2	4	2	5	27
V. auriculifera	0	0	4	6	2	0	11	1	0	0	2	10
M. arbutifolia	0	0	2	5	1	0	4	4	0	0	0	8
G. robusta	0	0	4	7	4	0	13	1	1	0	0	15
Total	0	**9**	**38**	**86**	**22**	**0**	**128**	**16**	**11**	**3**	**10**	**142**
Percentage	**0**	**5.8**	**24.5**	**55.5**	**14.2**	**0**	**82.6**	**10.3**	**7.1**	**1.9**	**6.45**	**91.6**

Upper tip condition – complete round (01), one side sharpened (02), fully sharpened (03)

4.2.4 Distribution of scent marks around civetry sites and pathways

Out of the total 155 scent markings observed, most of the scent marks (70.9%) were located between 1 – 5 meter from the civetry sites, whereas 25.2 % were marked at the distance less than one meter from the civetry. Only 3.87% markings were recorded from the distance above five meter from civetry site (Table 5). Findings of Melese and Balakrishnan, (2015) revealed that in the farmland and natural forest areas, scent marks were more distributed around civetries than in non-civetry locations. But, the present investigation indicated that in captivity more scent marks were distributed along pathways rather than around civetry sites.

Captive civets exhibited a tendency to scent-mark at higher frequencies on objects within 20 - 50cm from walkway (94.5%); only 5.5 % were found at distance above 50cm from footpath (Table 5). This support the earlier finding of Mulu *et al.* (2011) and Randall (1979). These authors reported that African civet markings were almost exclusively distributed along roads. Civets may prefer scent marking objects along their pathways, as these areas have higher chance of visibility for conspecifics.

The circumference of plant species used for scent mark was varied from 10 to 40 cm. Markings were frequently observed on rods with the circumference 10 – 20cm (81.9%), and no markings were observed on poles with circumference above 40cm (Table 5).

Table 5. Preference of rod circumference and distribution of scent mark

Species type	**Rod circumference**					**Distance from civetry**			**Distance form walkway**				
	<10cm	10 - 20cm	21 - 30cm	31 - 40cm	>40cm	<1m	1 - 5m	>5m	<20cm	20 - 30cm	31 - 40cm	41 - 50cm	>50cm
	Number of observations												
E. camaldulensis	3	25	0	0	0	5	22	1	0	15	8	3	2
C.anisata	0	16	5	1	0	5	17	0	0	19	1	0	2
C. macrostachyus	0	19	1	2	0	8	14	0	0	15	5	1	1
S. sesban	2	12	0	0	0	3	10	1	0	7	4	1	2
P. guajava	3	27	4	0	0	8	24	2	0	23	8	0	3
V. auriculifera	2	7	2	1	0	0	10	2	0	9	1	2	0
M. arbutifolia	0	7	0	1	0	4	4	0	0	7	1	0	0
G. robusta	0	14	1	0	0	6	9	0	0	11	4	0	0
Total	**10**	**127**	**13**	**5**	**0**	**39**	**110**	**6**	**0**	**106**	**32**	**7**	**10**
Percentage	**6.45**	**81.9**	**8.4**	**3.23**	**0**	**25.2**	**70.9**	**3.87**	**0**	**68.4**	**20.7**	**4.53**	**6.45**

Orientations of poles were also determined the scent mark preference by African civets. Out of the 155 scent marks observed during the present investigation, 137 (88.4%) were found to be

marked on vertically standing objects; only 18 (11.6%) were found to be marked on objects less than 90^{o}. Ewer and Wemmer (1974) found that vertical and horizontal surfaces were marked by tame civets. Wemmer (1977) recognized zoo civets marking vertical surfaces only.

4.2.5. Over-marking

In most cases, fresh markings (whitish-yellow in color) were observed directly on top of previously marked ones (dark brown). In all of their new and old trails, civets always move head lowered to the ground, sniffing and inspecting scent marks. Scents detected on the ground or on sign posts were vigorously over marked (Figure 11). Johanston *et al.* (1995) and Ferkin (1999) have explained this situation as "overmarking". Overmarking may indicate dominance of one member over another as observed in meerkat (Jordan *et al.,* 2007).

Figure 11. Overmarking

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The findings of this investigation have suggested that captivity influences greatly the behavior of African civets because of variable environmental factors such as resource availability, human contact, and lack of sufficient space. Wild civets are solitary with exception during mating time. However, captive civets where a number of individuals were existed together in the same enclosure could develop behavioural modification during the study time. More than two civets were able to feed from singe container, and even they were share the space where they sleep during day time. Such behavioural modifications were the result of repetitive exposure to one another for a long period of time.

Chemical communication is essential for normal social interaction and reproductive behavior. African civets used perineal secretions for the purpose of communication. In captive environments, civets used various objects to mark despite they preferred plant species with smooth texture and vertical orientation. Markings often observed along road side to left the message for other individuals.

5.2 Recommendations

To sustain the civet industry without depleting or negatively affecting the animals concerned and at the same time improving the livelihoods of the people involved in the production and export of the musk, the following measurements should be taken by concerned bodies.

- The concern of various government and non-government sectors should be the establishment of a model civiculture project.
- All behavioural patterns of both captive and wild civets should be studied. Traditional methods can be validated during these studies and appropriate husbandry practices identified.
- Traditionally, once a civet dies it is replaced with a civet from the wild. Efforts must be made to breed civets in captivity, and cubs born to captive civets should be domesticated. Civets that have been reared as cubs allow their owners to remove musk from their glands.

- To alleviate unnecessary harassment to captive animals during the process of musk extraction, rods with appropriate diameter and texture (preferable by civet) should be set in cages. Civets will rub their anal glands against them and musk will be deposited on it.
- To minimize the welfare problem in civet farming, extensive studies should have to be carried out both on wild civets and civets under captivity to gather information on distribution, numbers, breeding, and behavioural patterns.
- The present trapping methods, cage dimensions, feeding, musk extraction methods and general levels of animal care should be improved by educating civet farmers involved in civiculture practice.

6. REFERENCES

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

Anonis, D. P. (1997). Animal notes in perfumery: civet and civet compounds. *Perfu. And Flavou* .**22**: 44−47.

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

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

Berger,J., Stacey, P.,Bellis, L. and Johnson, P. (2001). A mammalian predator–prey imbalance: grizzly bear and wolf extinction affect avian Neotropical migrants. Journal of applied Ecology, **11**: 947–960.

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.

Burger, B.V. (2005). Mammalian Semiochemicals. *Top Cur Chem.,* 240 231–278.

Clive, R. (2007). Domestication. Greenwood Guides to the Animal World. GreenwoodPub Group, USA.

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**:

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

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

Darwin, C. R. (1868). *The variation of animals and plants under domestication*. Baltimore: Johns Hopkins University Press.

Delellegn, Y. (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.

Delellegn, Y. (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.

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.

EWCA (2013). Musk importing countries. Ethiopian Wildlife Conservation Authority, Report Addis Ababa.

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

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.

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.

Ford, A. T., A. P. Clevenger, and A. Bennett. (2009). Comparison of methods of monitoring wildlife crossing structures on highways. J. Wildl. Manage. 73, 1213–1222.

Formica, V.A., August, M.E., Barnard, M.E., Butterfield, R.E., Wood, C.W. and Brodie, E.D.(2010). Using home range estimates to construct social networks for species with indirect behavioral interactions. *Beh Ecol Sociobiol* 64: 1199–1208.

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.

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.

Gittleman, J. L. (1996). *Carnivore Behavior, Ecology, and Evolution.* Vol. 2. Cornell University Press, Ithaca.

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

Habtamu, T., Bekele, A., Ahmed, R., Gadisa, T., Birlie, B., Tolemariam, T. and Belay, B. (2017). Diets of the African Civet *Civettictis civetta* (Schreber, 1778) in selected coffee forest habitat, south-western Ethiopia. *African journal of Ecology*. pp 1 – 5.

Hannah J. O. and Andrew C. K. (2005). The effects of captivity on the morphology of captive, domesticated and feral mammals, *Mammal Rev* 2005, Volume 35, No. 3&4, 2 – 3.

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

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.

Jansen, P.A.; Forrester, T.D.; McShea, W.J. (2014). Protocol for camera-trap surveys of mammals at CTFS-Forest GEO sites. Smithsonian Tropical Research Institute. Center for tropical Forest Science.

Johnstone, R. A. (1999). The evolution of animal signals. In Behavioural Ecology: An Evolutionary Approach (ed. J. R. Krebs and N. B. Davies). Blackwell Science, Oxford.

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.

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.

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

Kindgon, J. (1997). *The Kingdon Field Guide to African Mammals*. Academic Press, London. 144

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.

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.

Lickliter, R., and Ness, J. W. (1990). Domestication and comparative psychology: Status and strategy. *J. Comp. Psychol.* 104:211 -18.

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.

Melese, D., Suryabhagavan, K.S., Gelet, M. 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.

Melese, D and Balakrishnan, M. (2015). Seasonal and Spatial Differences in Feeding Ecology and Behavior of the African Civet Civettictis Civetta in Arba Minch Forest, Arba Minch, Ethiopia. Global Journal of HUMAN-SOCIAL SCIENCE: H Interdisciplinary Volume 15

Mench, J. A. (1998). Why it is important to understand animal behavior. *ILAR J.* 39:20-26

Morgan, E.D. (2009). Trail pheromones of ants. *Phy Entomol* 34: 1–17.

Mohammed, J. (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.

Mullu, D. (2015). Scent-marking by the African Civet *Civettictis civetta* in Arba Minch Forest, Nech Sar National Park, Ethiopia**.** International Journal of African and Asian Studies ISSN 2409-6938. An International Peer-reviewed Journal Vol.10.

Müller-Schwarze, D. (1983). Scent glands in mammals and their functions. Pp. 150–197 in Eisenberg, J. F. & Kleiman, D. G. (eds) *Advances in the study of mammalian behavior*. Plenum Press, New York, U.S.A.

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

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.

Price, E. O. (1998). Differential reactivity of wild and semi- domestic deermice (*Peromyscus maniculatus*). *Anim. Behav.* 18:747-52

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

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. Mamml.* **60**: 622–627.

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

Ray, J.C. and Sunquist, M.E. (2001) Trophic relations in a community of African rainforest carnivores. *Oecologia*, **127**: 395-408.

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

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

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.

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.

R-Zu-2-U. (2000). *African Civet*. Online. 2pp. 21 June ’00. www.treasureranch.com

Scordato, E.S. and Drea, C.M. 2007. Scents and sensibility: information content of olfactory signals in the ring tailed lemur (*Lemur catta*). *J Anim Beh* 73: 301–314.

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

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.

Srbek-Araujo, A. C., Garcia A.C. (2005). Is camera-trapping an efficient method for surveying mammals in neotropical forests? A case study in south-eastern Brazil. J. Trop. Ecol. 21, 1-5.

Tadele, T. and Fikadu, R. (2007). The husbandry, welfare and health of captive African civets (*Vivera civetica*) in Western Ethiopia. Anim. Welfare, 16: 15-19.

Tsegaye, B, Bekele A. 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.

Tsegaye, B, Bekele A. 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.

Tsegaye, B. (2015). Feeding Ecology of the African civet *(Civettictis civetta)* and improved captive management for sustainable utilization in I*llubabora*. PhD Dissertation. Addis Abeba University.

Wakjira, K. (2005). Improving Civet Cat Farming for Quality Musk Production (Amharic version). Agriculture and Rural Development Bulletin, 2: 31–34.

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

Wemmer, C. (1977). Comparative ethology of the large-spotted genet *Genetta tigrina* and some related viverrids. Smithsonian Contributions to Zoology, 239: 1 – 93.

Williams, D. G. and Curtis, T. (1994). *Introduction to Perfumery*. Ellis Horwood Limited, London.

William J. **(**2003). The story of civet. *Pharmace. J.* **271**: 859–861

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

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

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.

WSPA, (1999). New report exposes cruel farming of musk for the perfume industry. Wildlife. http://ww2.wspa-international.org

WSPA (1998). *New Report Exposes Cruel Farming of Musk for the Perfume Industry*. World Society for the Protection of Animals, London.

WSPA, (2000). *Civet farming: an Ethiopian investigation*. World Society for the Protection of Animals, London, U.K.

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.

Yalden, D.W., Largen, M.J. & Kock, D. (1980) Catalogue of the mammal of Ethiopia: 4 Carnivora. Ital. J. Zool. 8, 169–272.

APPENDICES

Appendix 1. Field data sheet used for recording behavioural patterns of African civet

Behaviour	Activities	Month							
		Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
Social behaviour	Co-feeding								
	Co-walking								
	Sleep in group								
Aggressive behaviour	Fighting								
	Chasing								
Solitary behaviour	Feeding alone								
	Walking alone								
Other behaviours	Scent marking								
	Self grooming								
	Defecation								

Appendix 2. Field data sheet used for recording scent mark objects preference by African civets

Date _____

Species code	Length of the rod	Width of the rod	Distance from civetry	Distance form walkway	Height at which scent is marked	Rod texture	Upper tip condition			Angle of the rod			Frequency of scent mark	Distance b/n scent marking objects
							01	02	03	45^{o}	60^{o}	90^{o}		

- **Upper tip –** complete round (01), one side sharpened (02), fully sharpened (03)
- **Rod texture**- complete rough (01), partly rough & partly smooth (02), semi-rough (03), semi smooth (04), totally smooth (05)