JIMMA UNIVERSITY

COLLEGE OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGY

ASSESSMENT OF RODENT PEST DIVERSITY, RESIDENTS' PERCEPTION AND MANAGEMENT STRATEGIES IN JIMMA TOWN, SOUTH WEST ETHIOPIA

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Declaration

I, Hereby, declare that this thesis is my original work, that it is the documentation of work carried out by me and that it has not been submitted in any previous application for a higher degree .I announce that I have developed and written the enclosed master thesis completely by myself, and have not used sources or means without declaration in the text. Any thoughts from others or literal quotations are clearly marked. The master thesis was not used in the same or in a similar version to achieve an academic grading or is being published elsewhere. This has been submitted in partial fulfillment of the requirement for M.Sc. degree at Jimma University. I declare that this thesis is not submitted to any other institution anywhere for the award of academic degree. Wherever contribution of others are involved, every effort is made to indicate this clearly, with due reference to the literature and acknowledgement source made.

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Acronyms

ANOVA	Analysis of variance
EPA	Environmental Protection Agency
FGD	Focus Group Discussion
LF	Lassa fever
IPM	Integrated Pest Management
SPSS	Statistical package for social sciences

Abstract

The study focused on assessment of rodent pest diversity, residents' perception and management strategies in Jimma town, South West Ethiopia. Among the mammalian orders, Rodentia contains the largest number of species and they account for nearly 44% of the mammal species. They comprise 26 orders, 29 families, 443 genera and more than 2000 species. This study was conducted to assess the rodent pest diversity, residents' perception and management strategies in six selected kebeles of Jimma town. Representative kebeles and householders/residents were selected, using a random sampling technique. Rodent pest diversity survey was carried out from March, 2019 to July, 2019 during both dry and wet seasons. Rodents were collected using live and snap traps procedure from representative households in selected kebeles of Jimma town. A total of 162 rodents and insectivores (live traps) and 30 (snap traps) were captured from representative kebeles residents' house. Two rodent and two insectivore species were identified. The relative abundance of Rattus rattus,Mus musculus, Crocidura fumosa ,and Crocidura flavescens was 46.94%, 40.7%,8.2%and 4.32%,respectively. Majority of respondents believed that the people can catch diseases from mice and rats. Respondents know that dirtiness of the house environment, housing structural defects, high housing density, proximity of the houses to dumping sites and refuse bins facilitate the diversity of rodent pests and poor house management habits favor rodent pest proliferation contribute for the abundance of rodent pests were identified. The highest number of rodents were trapped in Bacho Bore kebele and the least numbers of rodents were caught in Hora Gibe. Strategies adopted by respondents to control rodent pests using traps (live and snap), environmental hygiene, use poison, block all rat hideouts, biological control and periodic fumigation were identified. Jimma town municipality should give required services in avoiding the solid waste in the appropriate place where the disposal should be properly handled.

Keywords/phrases: Rodent pests, Rodent diversity, Insectivores, Relative abundance, Traps.

1. Introduction

1.1. Background of the study

Among the mammalian orders, Rodentia contains the largest number of species (Kingdon, 1997; Vaughan *et al*., 2000; Tsegaye and Afework, 2006), and they account for nearly 44% of the mammal species (Wolff, 2007).They comprise 26 orders, 29 families, 443 genera and more than 2000 species (Vaughan *et al*., 2000; Danell and Aave-Olsson, 2002).There are nine families of rodents in Ethiopia of which the family Muridea alone comprises 57 species (84% of the total number of species) and 93% of the total endemic rodents of Ethiopia (Afework and Corti, 1997). Rodent community structure and species richness have been related to habitat structure and complexity, area of productivity, predation and succession of the vegetation (Avenant and Cavallini, 2008).

Rodents and insectivores are able to exploit a wide range of habitats and environments throughout the world (Lange *et al*., 2004; Vaughan *et al.,* 2000). At local scale, their distribution and abundance is influenced by vegetation structure and composition, which reflect the habitat condition (Worknehe*t al.,*2004; Kannan and James, 2009; Nowak, 1999).Habitat selection is considered an important factor in community dynamics (Shanker, 2001; Shurchfiesd, 1997). Habitat complexity, association and disturbance are other important factors affecting species diversity and distribution in natural ecosystems (Demeke *et al*., 2007b; Tadesse and Afwork, 2008; Kilgore *et al*., 2010; Obsom and Parker, 2003).

Rodents have economical, ecological value, and provide major benefits to our environment (Center for Disease Control and Prevention, 2005).Most species play great role in maintaining the ecosystem such as seed dispersal, pollination, predator-prey relationship and maintaining ecological balance and habitat modification (Masi*et al*.,2009). They are also important food source for human being (Tadesse and Afework, 2007).They make up the most important component of the diet of the Gumuz indigenous people in Ethiopia (Tadesse andAfework, 2008). There are about 71 rodent genera, representing more than 89 species that are consumed by man. They are preferred as a delicious food source in several countries of Africa because of rich protein content in their flesh (Fiedler, 1990).

Adversary, they are known to have multiple impacts, damaging field crops, causing post-harvest losses, contaminating stored food and water supplies as well as transmitting disease through contamination, through bites to humans and vectoring zoonosis (Kaukeinen *et al*., 2000; Kaukeinen and Colvin ,2008b).Corrigan (2006); Kaukeinen and Colvin (2007) have suggested that most of the cities are high at risk of rodent infestation, owing to high human density, old and aging infrastructure, impoverished neighborhoods, and budgetary constraints on public spending for housing, sewers, poor trash management, a utilities. Rodents have high potential to spread diseases (Meerburg*et al*., 2009), and a propensity to destroy structures and consumer goods, they remain viable threats to human health and commerce (Tobin and Fall, 2005). They are a long-standing problem throughout the world which disproportionately affects the urban poor through consuming and contaminating stored food, transmitting disease, damaging field crops and degrading the built environment.

Ecological studies and the practical control of rodent pests in rural agricultural settings have largely involved the use of rodenticides *(*Makundi *et al*., 1999). However, especially in urban parts of Africa, there were several constraints to their use. Primarily, rodenticides were not affordable for the rural poor who are most affected by rodent pests. Even when rodenticides are widely available, they are often used inappropriately leading to low efficacy, rodenticide resistance and to human health and environmental risks (Kaukeinen, 1994; Bennett *et al*., 2010).

Although a shift toward a philosophy of Integrated Pest Management (IPM) model may be emerging, little was known about the portion of commercial shops, food stores, and restaurants that actually practice the Integrated Pest Management model approach (detail cleaning, sealing up entry holes, scheduled inspections) versus resorting to the more traditional approach of applying an over-the-counter rodenticide, snap trap, or sticky trap. Therefore, identification of rodent pest diversity and perception of the resident towards them in Jimma town the purpose of this research. In additions, this study also assess the diversity relative abundance and taxonomic category of the pests,attitude of the residents about rodent pests, the environmental conditions contributing for high pest infestation, and the strategies they used to lower the problem was also be equally considered.

1.2. Statement of the problem

The rate of human urbanization, compounded by climate change and inefficient pest control is leading to a proliferation of rodent-related risks (Harvell *et al*., 2002). Low socioeconomic urban areas in developing countries are characterized by inadequate sanitation such as poor drainage of surface and household wastewater, indiscriminate garbage dumping and inadequate refuse collection, which provide breeding grounds, easy access to food and shelter for rodent and insect pests (Jassat *et al*., 2013; Nalwanga and Ssempebwa, 2011). Furthermore, poor sanitation such as having pit latrines instead of flush toilets and lack of functional draining systems have also been identified as risk factors for rodent infestation (Masi *et al*., 2009; Jassat *et al*., 2013). Other environmental variables that favor rodent infestation include the presence of accessible garbage which provides food and shelter, access points such as cracks and holes in the housing structure, and thick vegetation next to houses (Masi *et al*., 2009; Kelly *et al*., 2013).

Jimma town, the present study area is a capital of Jimma zone, one of the 18 zones of Oromia Nation Regional State towards the south western part of the country. Regardless of its old age (about 200 years), many parts of the town has poor infrastructure, sewage system and extremely poor constructions quality, 70% of which is mud houses. As already indicated Crrigan (2006);Kaukeinen and Colvin(2007), poor quality houses in association with poor solid waste management strategies are expected to contribute for fast reproduction and high rate of rodent pest infestation posing high risk for economic loss and human health hazards. However, there was no scientific evidence regarding the species diversity of rodent pests (including insectivores),resident knowledge and attitude towards these pests, the strategies and efficiencies of commonly used by residents to lower the risk of these pests. Therefore the present study attempted to assess the diversity of rodent pests in Jimma town, the knowledge and perception of residents towards these pests, and the traditional or modern strategies they used to lower the risk and the efficiency of the strategies from the selected kebeles(the smallest administrative unit in towns) in Jimma town, south western Ethiopia.

In doing so, the study tried to answer the following questions:

1. What are the rodent and insectivore pest species most common in Jimma town?
2. What is the attitude of residents of Jimma town towards rodent pest?
3. What is the knowledge of residents about contributing factors for high risk of rodent pest in the town?
4. What control strategies do residents use to minimize the impacts of rodent pests?

1.3. Objectives of the study

1.3.1. General objective

This study was intended to investigate rodent pest diversity, residents' perception about rodents and management strategies in Jimma town, southwest Ethiopia.

1.3.2. Specific objectives

- To identify the diversity of rodent/insectivore pest species in Jimma town.
- To determine the attitude of residents towards rodent pests in study area.
- To measure the knowledge of residents about contributing factors for high impacts of rodent pests.
- To identify strategies used by residents to lower impacts of rodent and insectivore pests in study kebeles.

1.4. Significance of the study

Rodent pests are major problems in cities and towns with poor infrastructure, house spacing and sanitation to which Jimma town is not exceptional. Understanding the diversity of major rodent and insectivore pest species and factors contributing for their abundance, the attitude of the resident towards these pests and strategies used to lower their impacts contribute to design effective measures to lower their impacts. The study will generate information on the current level of rodent pest problems and management strategies by the residents and provide firsthand information to the town to take appropriate management strategies, lowering the impact of rodent pests

2. Literature review

2.1. Diversity of rodent pests

The mammalian fauna of Ethiopia is under study (Afework and Yalden, 2014). Yet, with about 320 species currently recorded, the country is one of Africa's most diverse nations for mammals (Vreugdenhil *et al*., 2012). Among these, 36 species are endemic, about a quarter of which are large mammals (Afework,2014).Endemism even occurs at the level of genera with six endemic genera of mammals recorded so far of which four are monotypic (Mega dendromus, Muriculus, Nilopegamys, and Theropithecus) and the other endemic genera are Desmomys and Stenocephalemys (Vreugdenhil *et al*., 2012).

Rodents are the most diverse group of mammals (Vaughan *et al*., 2000).They show great diversity in their ecology, morphology, physiology, behavior and life history strategies (Nedbal *et al*., 1996). They are well adapted to a wide range of environments (Nowak, 1999). They are also the most diverse and abundant among mammals in Africa (Afework, 1996). There are 84 species of rodents in Ethiopia (Afework and Leirs, 1997). Of the total rodent species of the country, 21% are endemic. Small rodents of Africa are the most ubiquitous and numerous among mammals (Delany, 1986). There are about 14 families, 89 genera and 381 species of rodents in Africa (Singleton *et al*., 2007).

Rodents and insectivores are able to exploit a wide range of habitats and environments throughout the world (Lange *et al*., 2004; Vaughan *et al*., 2000). At local scale, their distribution and abundance is influenced by vegetation structure and composition, which reflect the habitat condition (Workneh*et al.*,2004; Kannan and James, 2009; Nowak, 1999).Habitat selection is considered an important factor in community dynamics (Shanker, 2001; Shurchfiesd, 1997). Habitat complexity, association and disturbance are other important factors affecting species diversity and distribution in natural ecosystems (Demeke *et al*., 2007b; Tadesse and Afwork, 2008; Kilgore *et al*., 2010; Obsom and Parker, 2003).

There are nine families of rodents in Ethiopia of which the family Muridea alone comprises 57 species (84% of the total number of species) and 93% of the total endemic rodents of Ethiopia

(Afework and Corti, 1997). *Lophuromys flavopunctatus* is also the most common rodent in the moist eastern part of East Africa inhabiting wide range of habitats (Clausnitzer and Kityo, 2001).

Most rodent species play great role in maintaining the ecosystem such as in seed dispersal, pollination, predator-prey relationship and in maintaining ecological balance and habitat modification (Masi *et al*.,2009).They are important food source for predators including the endangered and endemic Ethiopian Wolf(*Canis Semensis*) (Mohammed *et al*.,2010). Rodents are used important source of food in many parts of Africa. They make up the most important component of the diet of the Gumuz indigenous people in Ethiopia (Tadesse and Afework, 2008). There are about 71 rodent genera, representing more than 89 species that are consumed by man. Rodents are preferred as a delicious food source in several countries of Africa because of rich of protein content in their flesh (Fiedler, 1994).Despite of their ecological benefits some rodent species causes major economic losses in developing country like Ethiopia. Rodents are good subjects for study because of their great ecological, economical, medical and short lifespan (Delany, 1986; Kingdon, 1997; Dandrea *et al.*, 2007).

2.2 Rodents pose health and property risks

The need to understand and explore the risk perceptions of communities' are an important and often neglected area of urban rodent control programs. Only by establishing these factors can effective risk communication with the public be successfully undertaken. Previous attempts to involve local residents in control programs have reported varying degrees of success (Margulis, 1977; Colvin and Jackson, 1999; Lambropoulos *et al*., 1999). However, if communities were not centrally involved by ensuring their beliefs and perceptions of urban rodents were incorporated into control programs, then they may believe that rodent control is someone else's responsibility and that they have little to contribute to control programs. No single presentation format had been found to be unequivocally the best, and the preferred format appears to vary depending on whether the purpose of the risk communication effort was to educate and motivate people to take appropriate actions. Characteristics such as the audience's level of knowledge and education; their mental models, attitudes and beliefs about the issue at hand; their level of receptivity and openness to the ideas being communicated; and their concerns about the issue would also affect the way in which risks were communicated (Bier, 2001).

Rodents comprise a major part of virtually any ecosystem and were the most abundant class of living mammals, representing over the total mammalian species (Churakov *et al*., 2001).In addition to the economic losses associated with rodents destroying crops and farms, they had been estimated to be the reservoirs for up to 30 % of emerging zoonotic pathogens, including a host of viruses, bacteria, and parasites (Cleaveland *et al*., 2010).Rowan (1991) identified five possible goals of risk communication: building trust in the communicator; raising awareness (e.g. of the potential disease hazard of rodents); educating; reaching agreement (e.g. on a particular strategy for ensuring long-term control of rodent infestations); and motivating action (e.g. encouraging residents to adopt an integrated control strategy to reduce levels of infestation). Because of this multiplicity of purposes, different strategies of risk communication may be appropriate for different goals.

The success of both *Mus domestics* and *Rattus norvegicus*can be largely attributed to their ability to live in close association with man (Rowe, 1973). Although rats and mice had been found to harbor a wide array of pathogens, the actual magnitude of the public health threat posed by rodents remains unclear (Gratz, 1994; Childs *et al*., 1998). An understanding of the distribution, behavior and potential contact of urban rodents with humans were essential in trying to estimate this public health risk. Different perceptions in the attitudes of the public to rats and mice may influence the way in which they implement their own control strategies and such actions may inadvertently facilitate the establishment of chronic infestations. This study examined the perceptions of residents to rodents and examined the beliefs they had about approaches to treatments.

2.3. Level of rodent pest damage and mechanism of control

In developing countries rodent infestation poses a serious threat for reduction of income and widespread of food shortage by causing substantial damage to food and cash crops worldwide (Stenseth, 2001). In East Africa, rodent pest is mainly cause damage on cereal crops (Maknuid *et al*.,2003) and they have been ranked as major crop pest and become threat for national and international food security (Meheretu,2010). In Ethiopia rodents cause a great damage on cereal crops damage (Afework and Leirs, 2003). They adversely affect rural, communities by damaging their agricultural crop in the field and in the place of storage (Parshed, 1999). Dire

DawaAdministration (eastern Ethiopia) also experiences chronic rodent pest problems through the damage of different products and economically loss (Mohammed, 2011).

Because urban rats and mice exhibit high reproductive rates, have the capacity to spread diseases (Meerburg *et al*., 2009), and a propensity to destroy structures and consumer goods, they remain viable threats to human health and commerce (Tobin and Fall, 2004). Initial estimates by the United Nations in1982 reported that rats destroyed > 42 million tons of food worldwide that was worth $30 billion dollars. In the US, the economic cost of rat damage was estimated at $19 billion/year; many times greater than any other invasive animal species (Pimentel *et al*., 2000).

Controlling urban rodents, as other pests, requires the implementation of the Integrated Pest Management (IPM) model, which integrates monitoring, sanitation, physical intervention (exclusion, traps, repellents) and, if necessary, the application of rodenticides (Kaukeinen 1994; Bennett *et al*., 2010). As a result of Mayor Bloomberg's legislative agenda, novel approaches to rodent Integrated Pest Management (IPM) programs were developed for New York City, which include comprehensive neighborhood "indexing" (Corrigan, 2006;Bragdon *et al*.,2012), and where necessary the use of rodenticides. Nearly two decades ago, Buckle (1994) reported that the use of rodenticides was the primary approach of rodent control in urban and agricultural environments, and also predicted that this approach would continue in the foreseeable future.

Practical rodent pest management methods are now available for tropical crops in many areas, usually involving combinations of cultural practices and the strategic use of environmentally safe rodenticides. However, rodent species differences and ecological differences in crops and cropping practices in different areas still require the evaluation of methods in new practical use situations (Wood, 2001). In our earlier review, published work on rodent control, reflection of the overall research effort, was minimal, particularly in Central and South America, the Caribbean, Africa, the Middle East and the Far East (Kaukeinen, 2000).While the amount of new, practical information has increased somewhat, most current work continues to emphasize problem description or re-description rather than moving forward with the development of new practical rodent-control methods, thus leaving the continuing use of rodenticides the primary method of rodent damage control(Buckle, 1999; Singleton *et al*., 1999a;Stenseth *et al*., 2003).

Although relatively more publications, particularly on African rodent damage problems, have appeared (Leirs and Schockaert, 1997; Makundi *et al*.,1999), there are still a number of important crop damage situations for which no generally accepted rodent-control methods appear to be available or widely used (Stenseth *et al*., 2003).

Predators are nature's method of controlling rodent populations. There are many native and domestic predators that feed on rats and mice. Snakes such as king snakes, long nose snake, gopher snakes, and coach whips are non-poisonous native reptiles that feed primarily on rodents and may help control outdoor infestations (Corrigan and Robert , 2001). Hawks and owls, especially barn owls, eat large numbers of rats and mice. In general, dogs and cats are more effective at preventing an infestation than eliminating a current population. This is because they are better able to catch and kill an invading rodent that does not know any escape routes. Cats are very effective predators of mice, but usually will not attack an adult rat (Corrigan *et al*., 1997).Non-chemical methods can be used alone or integrated with rodenticide use when practical and cost-effective. Continuing research efforts are clearly needed so that effective rodent damage control is less dependent on the use of rodenticides as a primary method (Leirs *et al*., 1999). According to Kaukeinen *et al*. (2000) "householders" purchase about 40 to 50million household-use containers (i.e., off the shelves at nearby stores).

Poisoned bait is a common method for controlling rats, mice, birds, slugs, snails, ants, cockroaches and other pests. The basic granules, or other formulation, contains a food attractant for the target species and a suitable poison. For ants, a slow-acting toxin is needed so that the workers have time to carry the substance back to the colony, and for flies, a quick-acting substance to prevent further egg-laying and nuisance (Kaukeinen, 2000). Baits for slugs and snails often contain the molluscide metaldehyde, dangerous to children and household pets (Bennett *et al*., 2010).Warfarin has traditionally been used to kill rodents, but many populations have developed resistance to this anticoagulant, and difenacoumis often substituted *(*Flint et *al.*, 2017).These are cumulative poisons, requiring bait stations to be topped up regularly (Leirs *et al*., 1999).Poisoned meat has been used for centuries to kill animals such as wolves (Buckle, 1994). Poisoned carcasses however kill a wide range of carrion feeders, not only the targeted

species (Amduret *et al*., 1991).Raptors in Israel were nearly wiped out following a period of intense poisoning of rats and other crop pests *(*Newton Ian, 2010).

With the known health risks, environmental persistence and resistance of pesticides, alternative Pest control measures such as rat traps Roomaney *et al*. (2012) are increasingly being advocated as more suitable and effective means for pest control. Perhaps the most well-known environmentally friendly and sustainable method for pest control is integrated pest management(IPM),a holistic approach that uses biologic, chemical, environmental and behavioral-cultural methods to control pests (Himsworth *et al*., 2013a).

2.4. Resident attitudes towards urban rodent control and perception about urban rodent pest

As urban areas expand, humans drastically affect the ecological communities (Grimm *et al*.,2000; Radeloff *et al*., 2005; Theobald *et al*., 1997), both directly (e.g., Fuller *et al*., 2008;Lepczyk *et al.,* 2004) and indirectly (Baker *et al*.,2005). Because humans and wildlife both were components of urban ecosystems, conflicts can arise between humans and wildlife when both compete for the same resources (e.g., Hill *et al*., 2007; Krester *et al*., 2008). For example, Donnell and Nicola (2006) observed a majority of raccoons excluded from human residences were found again in man-made structures two months later. Smaller animals such as rodents often were perceived as pests and targeted for control. Control measures can focus on exotics (e.g., black or Norway rats(*Rattus rattus and Rattus novegicus*, respectively), house mice (*Mus musculus*) that are synanthropic, or relics of the urban development process itself, as well as native species (e.g., gophers, moles). Regardless of species, such control and the products used for it can be indiscriminant and also impact non-target species of particular interest in rodent control method was the use of anticoagulants, which inhibit blood from clotting and result in animals internally bleeding to death(Amduret *et al*., 1991).Common anticoagulant chemical compounds intended for indoor and outdoor (only in close proximity to structures) use include warfarin,brodifacoum, and bromadiolone (Kaukeinen,2000),which are marketed under several trade names.

The environment in which a man lives could influence his development and health. Among the common environmental determinants of health, poor hygiene and poor housing were pressing problems facing the urban cities (Karija *et al*., 2013).The resulting problem of unplanned urbanization and subsequent un-precedent population growth become more relevant to developing countries where policy for physical development and control merely exist on paper, without being implemented (Hala, 2013). For example Nigeria, with a population of about 140 million, an annual urban growth of 3.8% and a poor solid waste management system, could inevitably witness an upsurge in her number of urban slums (Omole, 2003). By the year 2025, about 61% of the world's population would be living in urban areas, especially in developing countries.

Lassa fever (LF) transmission can occur by direct contact or with the environmental contact of an arthropod vector (UN-Habitat, 2003). LF was caused by a single-stranded RNA virus (Lopez and Mathers, 2006; Lopez *et al*., 2001). The main feature of the fatal illness was impaired or delayed cellular immunity leading to fulminant tviraemia (Daniel *et al*., 2013). The natural hosts for the virus are multimammate rats (*Mastomys natalensis*), which breed frequently and were distributed widely throughout West, Central and East Africa (Lopez and Mathers, 2006).Thus, there was a need to improve community attitudes to preventive measures in relation to rodent control in households and communities. This could assist in ensuring better prevention and control of LF through environmental means.

2.5. Factors promoting rodent pest infestation

Pest infestations in homes are facilitated by multiple factors that allow access and proliferation of pests. These factors mainly have to do with 1) the physical structure of housing, 2) the immediate environment surrounding the dwelling unit. Substandard housing and unhygienic environment, factors common in low-income urban communities are recognized as having a negative effect on health (Bashir, 2002; Harpham, 2009) and can be facilitators for pest infestations. Looking at each of these two factors in turn, links to larger societal concepts of social and environmental justice and personal agency are drawn that show the complex interplay of pest promoting factors low socioeconomic urban areas.

2.5.1 Role of housing

The rapid urbanization in developing countries has led to a rapid rise in the number and size of informal settlements Bonner *et al.* (2007)) which are characterized by poor housing conditions. In these communities, housing is characterized by low quality building materials and deteriorating structures (Tshikotshi, 2009), making it easy for pests to gain entry into the home. Several studies conducted in developing countries have found that poor housing quality promotes home pest infestations. For example, in Sierra Leone, Kelly *et al*. (2013) and Bonner *et al.*(2007) report that the risk of contracting Lassa fever, a disease transmitted by rats, is directly linked to poor quality housing factors. Studies done in Sao Paulo, Brazil (Masi *et al*., 2009) and Johannesburg, South Africa (Jassat *et* al., 2013) also found that rodent infestation was linked to poor housing quality such as cracks in the walls and ceilings.

2.5.2 Impact of surrounding environment

Low socioeconomic urban areas in developing countries are characterized by inadequate environmental sanitation such as poor drainage of surface and household wastewater, indiscriminate garbage dumping and inadequate refuse collection, which provide breeding grounds, easy access to food and shelter for rodent and insect pests (Jassat *et al*., 2013; Nalwanga and Ssempebwa, 2011). Furthermore, poor sanitation such as having pit latrines instead of flush toilets and lack of functional draining systems have also been identified as risk factors for rodent infestation (Masi *et al.*, 2009; Jassat *et al*., 2013). Other environmental variables that favour rodent infestation include the presence of accessible garbage which provides food and shelter, access points such as cracks and holes in the housing structure, and thick vegetation next to houses (Masi *et al*., 2009; Kelly *et al*., 2013). These pest-favoring conditions are common in many poor urban areas in developing countries, from Johannesburg (Jassat *et al*., 2013) and Rustenburg, South Africa (Tshikotshi, 2009), Sao Paulo, Brazil (Masi *et al*., 2009) to Kampala, Uganda (Nalwanga and Ssempebwa, 2011).

3. Methodology

3.1 The Study area

This study was conducted in Jimma town, Southwestern Ethiopia. The town is located at 7°40'N latitude and 36^0 50’E longitudes. The altitude of the town ranges between 1718m to 2293 meter above sea level. The lowest altitude of town is at Boye and the high altitude also at Aba Jifar palace Jiren area. The annual rainfall of the last two years (2017-2018) ranges between 1456 and1800 mm, highest between June and August but the wet season extends to early November (Ethiopian National Meteorological Agency Jimma sub-branch Office, 2019).Small and unpredicted rainfall is also common within the dry season months (February–March). Temperature of the study area is known to fluctuate significantly; however, it mostly ranges between 11.3^0C and 29.50°C with mean daily temperature of 20°C (Ethiopian National Meteorological Agency Jimma Sub-Branch Office, 2019). According to Oromia forest and wild life enterprise of Jimma town administration branch, Jimma town has 239.1 hectors vegetation coverage. Similarly, Jimma town was taken as a center of commercial starting from the early18^{th}entury.Current population of Jimma town is estimated to be 200,000 with annual growth rate of 2.9%. The town has administrative kebeles (Jimma municipality, 2019).

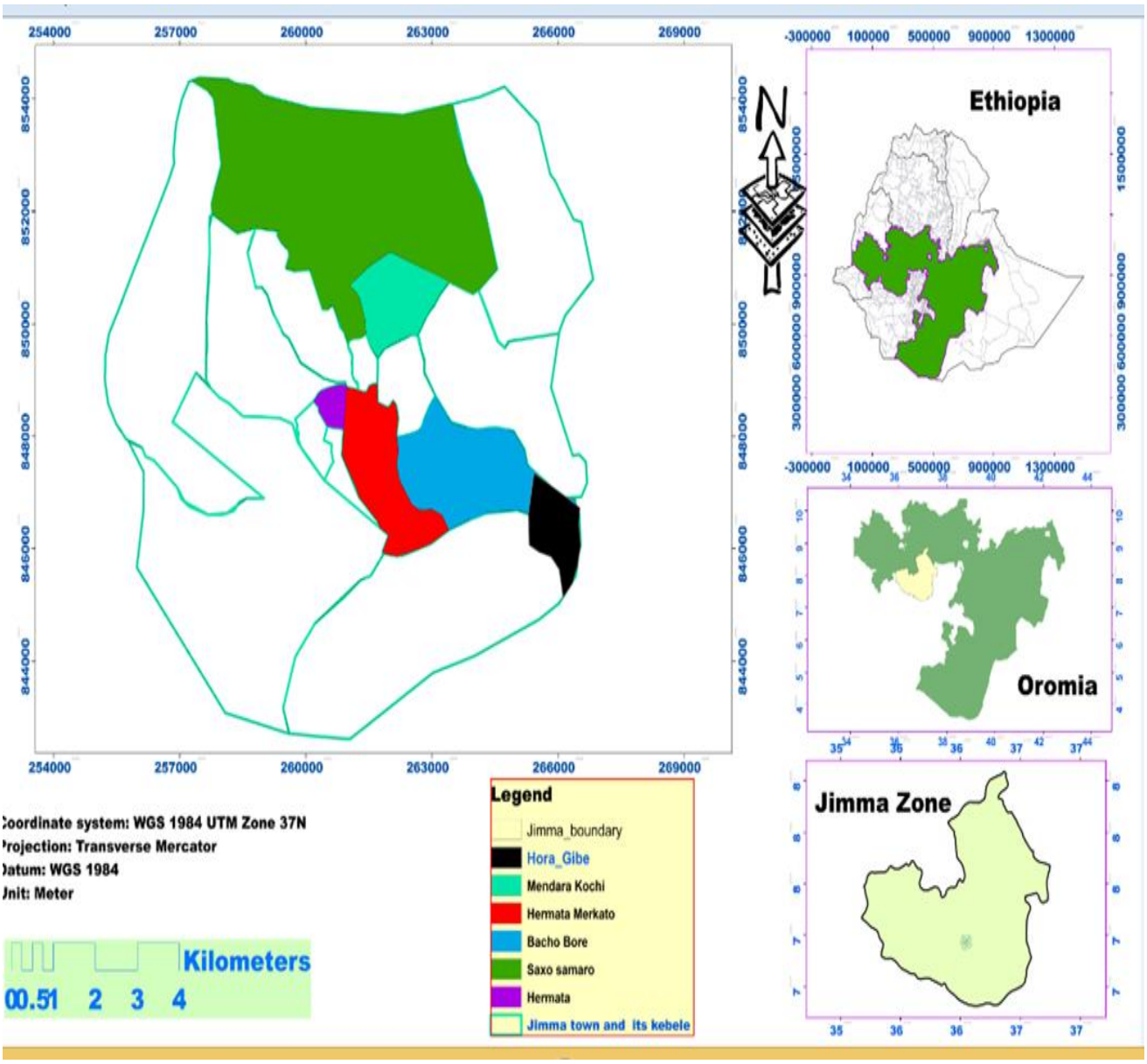

Figure 1 Map of the study area (Jimma municipality, 2019).

3.2 Materials and Methods

3.2.1 Materials

Materials used during the study were: live and snap traps, bait (peanut butter and barely flour with butter), spring balance, ruler, camera and gloves were used for body measurements. Live traps constructed of sturdy galvanized steel for maximum resistance to rust and corrosion, ultra-sensitive and spring control door and latch ensure. Escape proof: small mesh openings and door locked ensure the trapped rodent no way to escape. A snap traps made from metal and plastic with powerful snap hinge intended to kill rodents instantly on contact.

Figure 2.Live traps and others

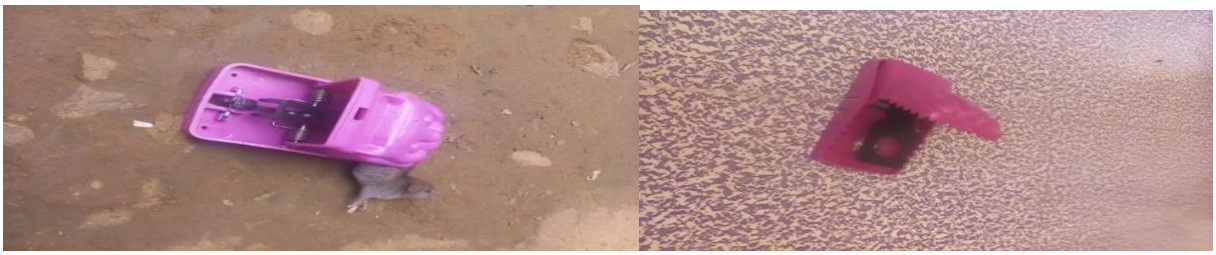

Figure 3. Snap traps

3.2.2 .Methods

3.2.2.1. Preliminary survey

Preliminary survey about the study area was conducted during March, 2019.During this period, survey on the availability and intensity of rodent infestation and all relevant information about the study area, kebeles of Jimma town, study kebeles, climatic conditions, and other environmental conditions were thoroughly assessed.

3.2.2.2 Sample population and sampling techniques

To select representative kebeles and residents or respondent used a multistage systematic random sampling technique was used (Daniel, 1999). Residents in the selected kebeles were invited to participate from March 2019to July2019 based on respondents' willingness to participate in the study.

3.2.2.3 Selection of study kebeles and households

Jimma town has 17 kebeles, of which, for this study purpose randomly classified into three categories. The first category includes Kebeles around the town center (referring the office of municipality), most commercial area. The second includes residential areas adjacent to the central area and the third category include kebeles located at periphery in all directions (Table 1).Then, two kebeles from each three categories were selected randomly based on the preliminary survey of the study kebeles and severity of rodents pests. These include, Herimeta,Herimeta Merkato, MenderaKochi, BachoBore, SatoSamaro and HoraGibe.

Table 1. Sampled selected kebeles of Jimma town in accordance with separate strata

No	Inner(Central) kebeles	Sampled kebeles	Middle kebeles	Sampled kebeles	Periphery kebeles	Sampled kebeles	Methods of selection
1	Herimata	Herimata	Bacho Bore	Menderak ochi	Jiren	Sato Samaro	stratum and random sampling methods
2	Herimata Mantina	Herimata Markato	Bosa Kito	Bacho Bore	Saxo Samaro	Hora Gibe	>>
3	Mantina		Ginjo		Ifa Bula		
4	Herimata Markato		MenderaKoc hi		Hora Gibe		>>
			Ginjoguduru		Kofe		
			Bosa Addis Ketama		Bore		>>
			Aweitu Mandera		Ginjo		>>
	Total=4	2	7	2	7	2	

The total numbers of householders in kebeles were 15,919. From this total size numbers of representative house holders/residents were determined using formula in (Daniel, 1999). The number of house holders in each kebeles varied based on differences in the number of residents. Thus proportional allocation of house holders in each kebele, equalized the representativeness of the kebele having larger as well as the smaller number of residents.

To determine sample size (n) with the desired degree of precession for general population were used. In this case population variable (p) was house unit's variable, so that Daniel (1999) sampling population formula was as follows:

Hence $\mathbf{n = \frac{NZ^2 PQ}{d^2 (N-1) + Z^2 PQ}}$

According to data obtained from housing development section of the town (2019), there were about 15,919 house holders (N) in the selected kebeles of Jimma town. Out of these more than 90% (P) were residential and the rest 10% (Q) was for commercial activities, offices and for others. Therefore, to determine the sample size of house holders,

Hence $\mathbf{n = \frac{NZ^2 PQ}{d^2 (N-1) + Z^2 PQ}}$

Where; n = the required sample size.

z^2 = degree of freedom at the desired confidence level or level of confidence (3.841).

Where, z=1. 96 then $z^2 = 3.841$

Q= 1-P

N = the population size.

P = Housing unit variable

d = Allowable error (0.03)

Therefore, n = 375 was the minimum sample size of house holders including in this study for reliable results.

3.3. Data Collection

3.3.1 Rodent pest diversity survey

To sample the diversity of rodent/insectivore pests in Jimma town, 16 live traps and 16 snap traps were used. In each selected households two live and two snap traps were set followed the droppings of rodents were observed in order to catch more rodents for two nights. Data were collected using live and snap traps during the dry and wet seasons. The dry seasons' data were collected in March, April and May 2019 in six sampled kebeles resident house and wet seasons in June and July 2019.The traps were be baited with a mixture of peanut butter, barley flour with butter. In each sampled kebeles' resident house, traps were checked for two nights early in the morning. Traps were cleaned and re-baited if consumed.

Rodents from the traps were transferred into bag information on the species, sex, approximate age (juvenile, sub-adult, adult), and the reproductive condition (i.e., closed or perforated vagina for females, and the position of testes for males) of the trapped rodents were recorded, finally live trapped rodents were killed to take standard body measurements. Only adult rodents were considered for body measurements.

Standard body measurements:-were taken after snap traps collection of the rodent pests.The collected rodents' body weight was measured by using a calibrated spring balance. Before starting the rodent pests measure the spring balance were calibrated to zero in each session of balance. Then the balanced weights were recorded according to the procedure (Kirsten, 2009).Head- body length:-was measured by using standard ruler. Before measuring the length, the rodent pests were made to be straight line along the animals' vertebral column, the measurements were taken from the tip of the nose to the middle of the anus. Then the measured head body length were recorded following (Kirsten, 2009).

Tail length was measured in straight line along from the middle of the anus to the tip of the tail. The tail length measurement was taken without suspending the animal or rodent pests (Aplin *et al*., 2003).Hind foot was measured from the heel to the tip of the central (longest) toe, but without including the claw. Ear length was measured from the bottom of the notch of the ear to the furthest point along the rim. The measurement was not taken if the margin of the ear was damaged as a result of fighting. All measured values were recorded according to standard procedures of (Singleton *et al*., 2007).

For species identification, taxonomic characteristics listed in Yalden *et al.* (1976) and Kingdon (1997, 2004) were used.

From the trapped animals

Abundance were computed=$\frac{\text{no of individuals pest species of trapped} \times 100}{\text{Total animals trapped}}$

3.3.2 Data to assess attitudes, knowledge and strategies of residents to control urban rodent pests

The data collection instruments/tools used in this study were focused on the attitudes of residents of Jimma town towards rodent pest was gathered using close ended questionnaires and independently filled by sampled respondents (Appendix I).On the other hand the knowledge of residents about contributing factors for abundance of rodent pest and strategies residents used and relative efficiency of each was assessed using close ended questionnaires, structured interview and focus group discussions. Structured interview was administered (face to face) with one of house hold (wife or husband) in each sampled houses. Random sampling technique was used for focus group discussions by non-gender differences in order to obtain relevant information about residents' management strategies of urban rodent in the selected kebeles of Jimma town. The focus group discussion was used as additional data collection from the kebeles residents' members. The researcher was form six groups for focus group discussion. There were seven members in all groups, which were make it a total of 42 (Appendix II, III).

3.4. Data analysis

Once the data were collected, a descriptive analysis was applied. Response frequency with respect to a given issue, percentages of the total number of respondents and frequency were used. Thus, to accomplish this, first responses of sampled residents were organized and tabulated into numerical data to be analyzed quantitatively. Then, closed-ended questions were directly be processed with SPSS software version 22.0 computer. The result of the interview and focus group discussion were analyzed in text explanations. One way ANOVA was used to compare body measurements among individuals of rodent and insectivore species and seasons.

3.5. Ethical consideration

To maintain the ethics requirement of the study, letter of permission was obtained from Jimma University Department of Biology to the respective informing institutions. Informed consent was secured from the informant officers concerned and thus respondents before interview. The respondents were given the privilege of not writing and/or mentioning their name and other identities to encourage them respond without hesitation and threat.

4. Results

4.1. Demographic characteristics of sample respondents

Among the respondents,137(36.53%) were males and 238(63.46%) of the respondents were females. Regarding their age, respondents 15-25(4%) years contributed the least of the study participant while 36-45(48%)contributedthe highest paritcipants. Regarding their educational status respondents from no formal education 61(16.27%) to respondents with second degree and above 9 (2.4%) participated in the study respectively (Table 2).

Table 2. Demographic characteristics of respondents

No	Variables	Alternative items	Frequency	Percentage(%)
1	Sex	Male	137	36.53
		Female	238	63.46
		Total	375	100
2	Age in year	15-25	15	4.00
		26-35	123	32.80
		36-45	180	48.00
		45 and above	57	15.20
		Total	375	100
3	Educational level	Noformal education	61	16.27
		1-4grade Complete	38	10.13
		5-8grade complete	80	21.33
		9-12 grade complete	70	18.66
		Certificate	65	17.3
		Diploma	32	8.53
		First degree	20	5.33
		Second degree and above	9	2.4
		Total	375	100

4.2. Rodent/insectivore pest species identified by live traps

162 small mammals belonging to the order Rodentia (Family: Muridae) and order Insectivore (Family: Soricidae) were trapped using live trapping techniques during both the dry and wet seasons from 375residents' houses of the six selected kebeles of Jimma town. From these two rodent and two insectivore species were identified. Both insectivores white toothed shrews. The rodent species recorded by live traps were *Rattus rattus, Mus musculus,* and the insectivores recorded were *Crocidura flavescecns* and *crocidura fumosa.*

The relative abundance of *Rattus rattus,Mus musculus*,*Crocidura fumosa* ,and *Crocidura flavescens* was 46.94%, 40.7%,8.2%and 4.32%,respectively.In BachoBore kebele, 25*R.rattus*, 18 *M.musculus, 3 C. flavescens* and 5 *C.fumosa* were caugh.t In Herimata, 11*R.rattus*, 10*M.musculus*, and *1C.fumosa* and 1*C.flavescens* were caught. In Mandara kochi, 10*R.rattus*, 8*M.musculus* and 3 *C.fumosa* were caught. In H/Gibe, 8 *R. rattus*, 8.*M. musculus* and1 C.*fumosa* were caught. In Seto Semero, 16 *R. rattus,* 10 *M. musculus*, 1*C.fumosa* and1*C.flavescens* were caught. In Herimata Merkato, 13 *R.rattus,* 12*M.musculusand,* 2*C.fumosa* were caught.

When compared the number of rodents caught in the six kebeles, the largest numbers of rodents were caught in Bacho Bore kebele and the second largest numbers of rodents were caught in Hermata Merkato and Setosemero. The least numbers of rodents were caught in Hora Gibe. *R.rattus*, *M.musculus* and *C.fumosa* were recorded from six sampled kebeles of Jimma town but *C.flavescens* recorded only from four sampled kebeles of Jimma twon(Table 3). (For more information see ***annex 1***)

Table 3. Distribution of rodent and insectivore pests in six sampled kebeles

Species	Sex		B/Bore	M/Kochi	H/Merkato	H/Gibe	S/Samero	Herimata	total	Abundance %
	M	F								
Mus musculus	39	27	18	8	12	8	10	10	66	40.7
Rattus rattus	38	38	25	10	13	8	16	11	76	46.9
Corcidura flavescens	2	5	3	-	2	-	1	1	7	4.32
Crocidura fumosa	7	6	5	3	2	1	1	1	13	8.02
Total	86	76	46	21	27	17	28	23	162	100

4.3. Rodent/insectivore species identified by snap traps

30 small mammals were captured from residents' house of the six sampled kebeles of Jimma town by snap trapping both dry and wet seasons. Out of these 24 of were rodents representing 2 species and 6 of were insectivores. From the captured species *Rattus rattus*comprised43.33%the largest proportion followed by *Mus musculus* 36.6%, *C.flavescens* and *C.fumosa* comprised 13.33% and 6.66% respectively.

The mean standard body measurements for the 6 snap trapped rodents are given in Table 4. Variation in the mean body weight among individuals of species and between seasons was statistically significant ($P<0.05$). However, there was no significant difference in the external body measurements of individuals of, species and between seasons ($P>0.05$).

Table. 4. Rodents caught by snap traps and their body measurements (Mean + SD)

Species	Seasons	No	Body measurements				
			B. W (g)	H. B (cm)	T.L(cm)	H. F(cm)	E.R(cm)
R.r	Dry Wet	6 7	53.6±7.6 61± 11.8	13.0±0.7 12.3±0.9	17.5±1.2 16.2±1.4	2.6±0.2 2.5±0.4	2.3±0.5 2.1±0.4
M.m	wet dry	6 5	36.7±9.6 33.6±8.6	12.3±0.9 11.6±0.8	10.3±0.3 9.5±0.3	2.4±0.4 2.5±0.2	2.4±0.2 2.5±0.2
C.fl	Dry Wet	2 2	12.1±0.5 10±0.4	8.1±0.3 7.8±0.1	5.3±0.1 5±0.1	1.3±0.2 1.5 ±0.1	1.3±0.1 1.3±0.1
C.fu	Wet	2	9.2±0.3	8.1±0.3	5.1±0.1	1.4±0.2	1.3±0.2

BW=body weight, HB= head body length TL= tail length, HF= hind foot Length, ER= ear length,*R.r = Rattus rattus, M.m=Mus musculus, C.fl=Crocidura flavescens ,C.fu= Crocidura fumosa.*

Table 5. Photos of rodents and insectivores that recorded from six sampled kebeles of Jimma town

Common name	Scientific name	Photos of rodents and insectivores
House rat	*Rattus rattus*	
House mouse	*Mus musculus*	
Musk shrew	*Crocidura flavescens*	
Grass shrew	*Crocidura fumosa*	

4.4. Attitude of residents' about urban rodents in Jimma town

As indicated in Table 6, 5 items related to urban rodents in Jimma town were prepared to collect information about resident attitude about rodent pests. Majority of respondents (75.99%) believed that the people can catch diseases from mice and (75.96%) believed that the people can catch diseases from rat. Regarding easy to get rid of rodents 78.6%respondents believed that it is not easy to get rid of rodents. 70.66% believe that if their neighbor has mice then they are likely to get mice. There was a fairly even split between those who agreed 74.67% and disagreed 25.32% with the statement that rodents are more likely to live in dirty houses.

Table.6 Attitude of residents about urban rodent pests in Jimma town

No	Variables	Valid	Frequency	Percentage
1	People can catch diseases from mice	strongly agree	185	49.33
		Agree	100	26.66
		Undecided	50	13.33
		Disagree	20	5.33
		strongly disagree	20	5.33
		Total	375	100
2	People can catch diseases from rat	Strongly Agree	184	49.06
		Agree	101	26.9
		Undecided	50	13.33
		Disagree	25	6.66
		strongly Disagree	15	4.0
		Total	375	100
3	It is easy to get rid of rodent	Undecided	80	21.33
		Disagree	195	52
		strongly disagree	100	26.6
		Total	375	100
4	If my neighbor has rat I will get rat too	strongly agree	165	44
		Agree	100	26.66
		Undecided	60	16
		Disagree	25	6.66
		strongly disagree	25	6.66
		Total	375	100
5	Rodents are more likely to live in dirty houses	strongly agree	190	50.67
		Agree	90	24.00
		Disagree	75	19.99
		strongly disagree	20	5.33
		Total	375	100

4.5 Residents' source of information about urban rodents

According to the response of the study participants, the majority of the respondents (78.67%) had got information about rodents from text books and 21.33% had heard about rodents from health care workers. Most of them (62.40%) reported that they see rodents in their house within the previous 24 hours, while others 32.00% reported that they see rodents over the past month and 5.60% claimed to never have seen a rodents in their house. Most of them (77.60%) said that rodents moved freely in their houses, while (78.13%) reported that they often saw rodents cross between houses (Table 7).

Table 7.Resident's source of information about urban rodents

No	Variables	Valid	Frequency	Percentage
1	What are the sources of information about rodents	Textbooks-	295	78.67
		Health care workers	80	21.33
		Total	375	100
2	Respondents seeing a rodent in their household	In the last 24 hours	234	62.40
		Over the past month	120	32.00
		Never	21	5.60
		Total	375	100
3	Rodents move freely in my house	Yes	291	77.60
		No	84	22.4
		Total	375	100
4	Rodents often seen crossing between houses	Yes	293	78.13
		No-	82	21.86
		Total	375	100

4.6. Waste management practices of the residents

As described in Table 8, 4 items related to waste management practice of residents' were designed and responses were collected and analyzed. According to the response of the respondents52% reported that they clean their house every day, 26.66% responded that they clean with two days interval. Many of them 49.33% responded that they remove accumulated waste twice a week, 21.33% reported that removing accumulated waste weekly. Regarding solid waste storage materials48% reported that they use two materials. Majority of respondents (66.7%) reported that the types of solid waste storage materials were sack and basket.

Table 8.Participants response about waste management practices

No	Variables	Valid	Frequency	Percentage
1	How often do you clean your house?	Every day	195	52.00
		With two days interval	100	26.66
		With three days interval	60	16.00
		With one week interval	20	5.33
		Total	375	100
2	How often you remove accumulated garbage?	Twice a week	185	49.33
		Weekly	80	21.33
		Monthly	60	16.00
		Daily	50	13.33
		Total	375	100
3	How many solid waste storage materials do you use to store solid wastes produced in your dwelling?	2	180	48.00
		3	100	26.66
		5	50	13.33
		1	45	12.00
		Total	375	100
4	What type of solid waste storage material do you use in your house to store solid waste produced from your dwelling?	Sack	170	45.33
		Basket-	80	21.33
		Metal container	65	17.33
		Plastic container ('festal'	60	16.00
		Total	375	100

4.7. Respondents' knowledge about the contributing factors for abundance of rodent pests

As indicated in Table 8, 5 items related to the house management and environment as factors contributing for abundance of rodent pests were designed to collect information about resident knowledge toward these factors. According to the response of the study participants the majority of the respondents (86.13%) believed that cleanness of the house environment can minimize the abundance of rodent pests. Most of respondents (88%) agreed that house management can also reduce rodent pest abundance. Regarding the good structure of the wall of the house 94% believed that good structure of wall can reduce rodent pest abundance. Most of respondents (73.49%) agreed that avoiding proximity of neighboring houses might reduce rodent pest entry. Most of participants (94.4%) agreed that housing quality and location minimize abundance of rodent pest.

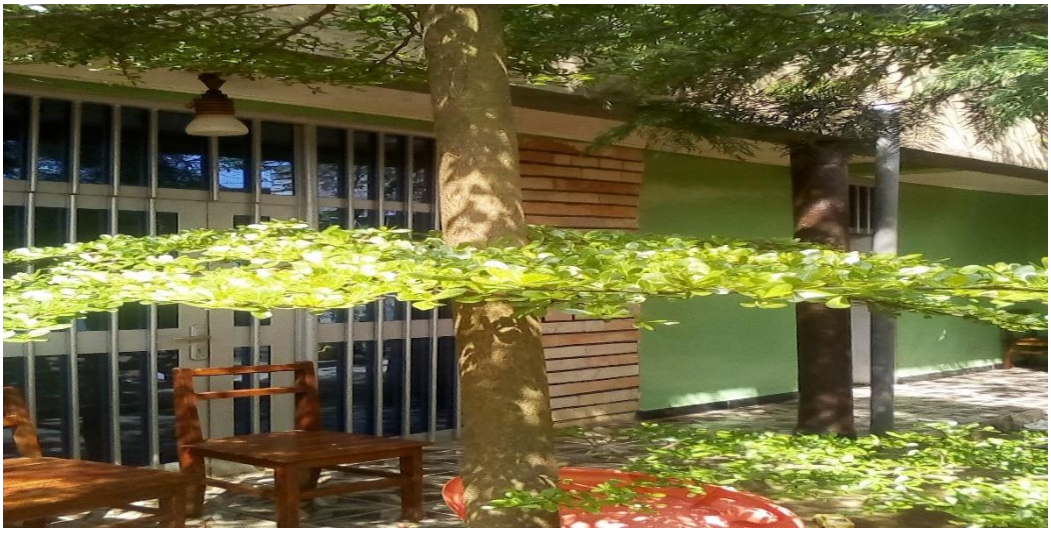

Figure 4 The good structure of the wall of the house

Table 9.Respondents ‘knowledge about the house structure and clean environment of the house on the abundance of rodent pests

No	Variables	Valid	Frequency	Percentage
1	The cleanness of the house environment can minimize the abundance of rodent pests.	strongly agree	189	50.4
		Agree	134	35.73
		Undecided	52	13.86
		Total	375	100
2	The good house management can minimize the abundance of rodent pests	strongly agree	189	52.80
		Agree	135	36.00
		Undecided	42	11.20
		Total	375	100
3	The good structure of the walls of the house can reduce the abundance of rodent pests	strongly agree	201	53.60
		Agree	154	41.06
		Undecided	20	5.33
		Total	375	100
4	Avoiding proximity of neighboring houses might reduce rodent pest entry	Strongly agree	179	47.73
		Agree	97	25.76
		Undecided	59	15.73
		Disagree	40	10.66
		Total	375	100
		Agree	115	30.66
		Undecided	17	4.53
		Total	375	100
5	Housing quality and location minimize abundance of rodent pests	Strongly agree	237	63.20
		Agree	117	31.20
		Undecided	21	5.6
		Total	375	100

4.8. Participants' knowledge about the bad house structure on the abundance of rodent pests

As it was indicated, 5 knowledge items related to the bad house structure, management and unclean environment of the house on the abundance of rodent pests as the factors abundance of rodent pests were designed and responses were collected and analyzed. Regarding the dirtiness of the house environment (96.8%) believed that the dirtiness of the house environment can increase the rodent pest. Most of participants (94.39%) reported that the poor house management can increase the abundance of rodent pest. Majority of respondents (92.80%) believed that the housing structural defects allowed for entry of rodent pest. Regarding the high housing density 70.13% agreed that the high housing density facilitated the movement of rodent pest between houses. Most of them (76.53%) believed that proximity of the houses to dumping sites and refuse bins facilitate the diversity of rodent pest (Table 10).

Figure 5 Housing structural defect

Table 10. Participants 'knowledge about the bad house structure and unclean environment of the house on the abundance of rodent pests

No	Variables	Valid	Frequency	Percentage
1	The dirtiness of the house environment can increase the rodent pests	strongly agree	231	61.60
		Agree	132	35.20
		Undecided	12	3.20
	Total		375	100
2	The poor house management can increase the abundance of rodent pests	strongly agree	197	52.53
		Agree	157	41.86
		Undecided	21	5.60
		Total	375	100
3	Housing structural defects allowed for entry of rodent pest	strongly agree	183	48.80
		Agree	165	44.00
		Undecided	15	4.00
		Disagree	12	3.20
		Total	375	100-
4	High housing density facilitated the movement of rodent pests between	Strongly agree	116	30.93
		Agree	147	39.20
		Undecided	78	20.80
		Disagree	34	9.06
		Total	375	100
5	Proximity of the houses to dumping sites and refuse bins facilitate the diversity of rodent pests	strongly agree	98	26.13
		Agree	189	50.40
		Undecided	60	16.00
		disagree	28	7.46
		Total	375	100

4.9. Strategies adopted by respondents' on urban rodent control

Live trap and snap were used by 48%, environmental hygiene was used 56%, poisons were used by41%, block all rat hideout were used by 72%, store grains, food items in containers with cover were used 60%, keep pets in the house were used 42%, periodic fumigation were used 34.66%, poison and snap traps were used by 57.33% (Table 11).

Table 11. Strategies adopted by respondents' on urban rodent control

No	Variables	Valid	Frequency	Percentage%
1	Use live trap and snap trap only	Yes	180	48.00
		No	195	52.00
		Total	375	100
2	Environmental hygiene	Yes	210	56.00
		No	165	44.00
		Total	375	100
3	Use live trap only	Yes	350	93.33
		No	25	6.66
		Total	375	100
4	Use poison only	Yes	155	41.33
		No	220	58.66
		Total	375	100
5	Block all rat hideouts	Yes	270	72.00
		No	105	28.00
		Total;	375	100
6	Store grains, food items in containers with cover	Yes	225	60.00
		No	150	40.00
		Total	375	100
7	Keep pets in the house	Yes	160	42.66
		No	215	57.33
		Total	375	100
8	Periodic fumigation	Yes	130	34.66
		No	245	65.60
		Total	375	100
9	Use poison and snap trap	Yes	215	57.33
		No	160	42.67
		Total	375	100
		No	280	74.60
		Total	375	100

4.10. Results of interview

The questions designed for interview focused on the perception and knowledge of residents' on urban rodents, the contribution of housing quality and location for the abundance of rodent pests, collection, transportation and disposal service for solid wastes, the presence of the residents clear and adequate awareness about solid waste management systems, the recommendations that should be done to improve the situation of environmental solid waste management system of the town to alleviate rodent impacts in general, the types of the strategies used to control the impacts of urban rodents by residents of selected kebeles of Jimma town and factors that promoting rodent pest infestation.

The responses of the interviewee were similar with the result of the questioners in that their responses indicated that the housing quality and location contribute for the abundance of rodent pests, collection, transportation and disposal services were not provided as required. The residents of Jimma town did not have clear and adequate awareness about solid waste management systems as expected. Different types of the strategies used to control rodent pests although it was not as required and the recommendations given by the respondents had indicated that disposal services should be given as required for the residents.

4.11. Results of focus group discussion (FGDs)

The designed focus group discussion questions focused on the way residents' think about urban rodents in their kebele, the extent at which residents are aware about urban rodents in their kebele, identify the types cause and damage of the rodent pests to the building, infrastructure, the types of the condition of households' solid waste management practices in Jimma town that help to minimize rodent borne-diseases, the strategies used to control the impacts of urban rodents by residents of selected kebeles of Jimma town poison, traps and other used to control the problem.

The response of all the FGDs discussants were almost similar in that discussants response indicated the response of rodents in their kebeles, damage of buildings, infrastructure by rodent pest. Discussants reported that rodents are dangerous animals. Rodent pest cause discomforts during their feeding, gnawing and sound production. They produce noisy sound in the walls, attics and ceiling during their scampering, running, scratching, gnawing, grooming, playing and fighting that result in discomfort and sleepless particularly during the night time. They cause direct damage to various commodities by gnawing, feeding, and indirectly damage by spoilage, contamination and deterioration. The residents of Jimma town did not have clear and adequate awareness about solid waste management systems as expected. Different types of the strategies used to control rodent damage were the use of cat, trap and poison but it was not as required.

5. Discussion

Small mammal species diversity is rich in many areas compared to the large mammal species diversity. Rodent species are particularly abundant, not only in natural habitats but also in man-made habitats, in habitats with human interactions and in human dwellings (Lavernchenko *et al*., 1998). Two rodent and two insectivore species were identified. The rodent species were the House mouse *(Mus musculus*), the house rat *(Rattus rattus)* and both insectivores white toothed shrews *Crocidura flavescens* and *Crocidura fumosa* were identified in selected kebeles of Jimma town.

The species *Rattus rattus* recorded from the six sampled kebeles of Jimma town in both dry and wet seasons. Singleton *et al*. (2007) reported it is a global commensal rodent that frequents around human settlement areas, farmlands, and feeds in both fields and houses. As revealed by Afework (1996b), it was a plentiful species in areas of human habitation. This might be associated with the adaptability of the species to the modified and anthropogenic habitats (Auffray *et al*., 2009).

The species might make a visit to farmlands and back to human habitations based upon the availability of food and ground cover in line with the previous study (Douangboupha *et al*., 2009).The current study disagree with Mulugeta (2013) who stated that *R.rattus* found only in the farm land especially from the maize farm. The present study in line with Selvaraji and Archunan(2002) who stated that *R.rattus* commonly inhabits near the human habitation. The more abundant species of rodent in the present study kebeles was the house rat, (*R.rattus)*. Bacho Bore kebele with high trap success than Hora Gibe. Bacho Bbore kebele had high contributing factors for abundance of rodent pests such as, housing structural defects, high housing density and poor solid waste management strategies in line with the study conducted by (Garba, 2014).

The species *Mus musculus* recorded from the six sampled kebeles of Jimma town in both dry and wet season. *Mus musculus* is known to occur in open habitats between altitudinal ranges of 1500-3000m asl (Yalden, 1988a). Bates (1988) stated that this species is exclusively urban and village dweller in line with present study. The house mouse (*M. musculus*) is reported to be abundant in

human settlements and more abundant in maize farm than in bushy habitats (Demeke *et al*., 2007). Yalden (1988) described *Mus musculus* as a widely distributed species in Ethiopia. During wet seasons *Mus musculus* migrate into human settlements, when there is inadequate food and cover are forced to migrate to areas where food and shelter are available (Tsegaye and Afework, 2006).The house mouse *(Mus musculus*) and the house rat (*Rattus rattus*) have worldwide distribution because of their association with humans and their adaptation to human habitats (Auffray *et al*., 2009).

The species*Crocidura flavescens*was earlier recorded from forest area in east Gojjam, Ethiopia (Moges and Dessalegn, 2015).*Crocidura flavescens* in the present study area trapped from four sampled kebeles of Jimma town. The species is one of the most common and widely distributed among insectivores in Ethiopia within altitudinal ranges of 1000-3000 m asl (Yalden *et al*., 1976).

Yalden *et al*. (1976) reported that *C. fumosa* was confined to altitudinal ranges of 1750-3900 m asl in Ethiopia. It was considered as a moorland species (Yalden, 1988b).Tadesse and Afework (2008) recorded few individuals of this species from Alatish Proposed National Park in areas of altitude < 700 m. a. s l. This species was earlier recorded in Jiren Mountain forest, Jimma area Ethiopia (Tadesse and Afework , 2013). The present study recorded two species of insectivore from the same genus (*crocidura)* in selected kebeles of Jimma town residents' house as commensal species.

The result of body measurement shows a significant variation in the mean body weight of rodents among individuals of species and between seasons. Similar result was observed by (Mossisa, 2010). This might be associated to the limited availability of food sources during the dry season compared to wet season.

Attitude of residents about urban rodents in Jimma town had indicated that majority of respondents (75.99%) believed that the people can catch diseases from mice and rats.
Similarly according to Meerburg *et al*. (2009), noted that rodent –borne diseases and their risks for public health. Regarding easy to get rid of rodent 78.6% respondents did not believed that easy to get rid of rodents. The present study in line with the finding of (Margulis 1977; Colvin and Jackson1999; Lambropoulos *et al.*, 1999).

The high levels of agreement that if their neighbor has mice then they are likely to get mice 70.66% suggests that respondents appreciate the importance of constructional features in facilitating infestations and the need to treat all properties in a block similar finding with (El-Yugud*aet al*., 2009). The majority of respondents (74.67%) believed that with the statement that rodents are more likely to live in dirty house similar finding with Hodges (2001), who stated that dirtiness of the house increase rodent pest abundance. Rodent pests cause discomforts during their feeding, gnawing and sound production. They produce noisy sound in the walls, and ceiling during their scampering, running, scratching, gnawing, grooming, playing and fighting that result in discomfort and sleepless particularly during the night time**.** The present study in line with the finding of (Mohammed, 2011).

Residents' source of information about urban rodent indicated that the sources of information about rodents' text book, health care workers and TV/radio were identified. The present study is similar with finding of (Aigbiremolen *et al*., 2012). 62.40% respondents reported seeing a rat in their houses within the previous 24 hours, while other 32.00% reported that seeing a rat over the past month and 5.60% claimed to never have seen a rat in their houses. 77.60% respondents said that rats moved freely in their houses, while 78.13% reported that they often saw rats cross between houses. The current study in line with the finding of (El-Yuguda *et al*., 2009).

Waste management practice of residents shown that they clean their house every day and with two days interval according to the significant percent of responses, they remove accumulated garbage twice a week and weekly, and solid waste storage materials have been used to store solid wastes produced in their dwelling and the type of solid waste storage material used in their house to store solid wastes were sack and basket. The present study comparable with finding of Karija

*et al.(*2013), in that in their finding they had identified as poor hygiene, poor housing quality and poor solid waste disposal are pressing problems in managing urban rodents.

Respondents' knowledge about the contributing factors for abundance of rodent pests had indicated that the cleanness of the house environment, the good structure of the walls of the house, avoiding proximity of neighboring houses, housing quality and location minimize abundance of rodent pests. The present study in line with finding of Aigbiremolen *et al*. (2012), in that in their finding they had identified avoiding proximity of neighboring houses minimize abundance of rodent pests. This result was similar with the result of rodent pests trapping, the least numbers of rodents that were caught in Hora Gibe. Hora Gibe kebele had less contributing factor for abundance of rodent pests compare to Bacho Bore kebele.

Respondents' knowledge about bad house structure and unclean environment of the house on the abundance of rodent pests had shown that the dirtiness of the house environment, housing structural defects, high housing density, proximity of the houses to dumping sites and refuse bins facilitate the diversity of rodent pests and poor house management habits favored rodent pest proliferation were factors that have been contributing for the abundance of rodent pests. The current study agreed with the finding of Masi *et al*. (2009) and Kelly *et al*.(2013), stated that the contributing factor for abundance of rodent pests, proximity of the houses to dumping sites and refuse bins facilitate the diversity of rodent pest. Similarly according to Bonner *et al*.(2007),reported that rodent pest diversity facilitated by poor housing conditions.

The highest number of rodents was trapped in Bacho Bore kebele and the least numbers of rodents were caught in H/Gibe. When compared the two kebeles, H/Gibe kebele had less contributing factors than Bacho Bore kebele. Bacho Bbore kebele had high contributing factors such as housing structural defects, high housing density, sewage system and poor solid waste management strategies. The result of the present study in line with Jassat *et al*. (2013), also found that rodent infestation was linked to poor housing quality such as cracks in the walls and ceilings.

Strategies adopted by respondents on urban rodent control, live and snap traps were used by 48% similar finding with Roomaney *et al*. (2012),noted that the acceptability of rat trap use over pesticides for rodent control in poor urban communities. Environmental hygiene was used 56%, use poisons were used by 41%, block all rat hideout were used by 72%, store grains, food items in containers with cover were used 60%, keep pets in the house were used by 42%, periodic fumigation were used by 34.66%, poison and snap trap were by 57.33%.The present study in line with finding of (Kaukeinen 1994; Bennett *et al.* 2010).

Finally, when triangulating the result that obtained through quantitative data collecting approach and qualitative data collecting approach as well as the result that obtained through trapping rodents, were confirming and supporting each other. This current study was different from the previous study that had conducted by Donnell and Nicola (2006) observed a majority of the rodent species were raccoons. The result of this current study was similar in the contributing factor with the study that had been conducted Karija *et al*. (2013) in that in their finding they had identified as poor hygiene, poor housing quality and poor solid waste disposal are pressing problems in managing urban rodents.

6. Conclusion and Recommendations

6.1 Conclusion

The present study has revealed that the diversity of rodent and insectivore pest species abundance varied in different study kebeles. The highest number of rodents were trapped in Bacho Bore kebele and the least numbers of rodents were caught in Hora Gibe both during the wet and dry seasons. Respondents believed that the people can catch diseases from mice and rats. Participants know that dirtiness of the house environment, housing structural defects, high housing density, proximity of the houses to dumping sites and refuse bins facilitate the diversity of rodent pests and poor house management habits favor rodent pest proliferation contribute for the abundance of rodent pests. Strategies adopted by respondents on urban rodent control were use traps (live and snap) only 48%, environmental hygiene 56%, use poison 41% block all rat hideout 72% , store grains, food items in containers with cover 60%, keep pets in the house42% and Periodic fumigation 34%were used.

6.2. Recommendations

Based on the above findings, the following recommendations were given as follows:

- Residents should keep the cleanness of the house environment to minimize the abundance of rodent pests.
- Jimma town municipality should give required services in avoiding the solid waste in the appropriate place where the disposal should be properly handled.
- Residents should use live and snap traps.
- Awareness should given by concerned body the way how to control the impacts of rodent pests to the residents.

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Appendixes

JIMMA UNIVERSITY

COLLEGE OF NATURAL SCIENCES

DEPARTMENT OF BIOLOGY

Questionnaire prepared for sample residents in Jimma town

Specifically the objective of the study will be to assess rodent pest diversity (including insectivore) residents 'perception and management strategies in Jimma town, selected kebeles, southwest Ethiopia.. Therefore, your response is very important for the success of the study because all information that you provide determines the analysis and conclusion of the research. Hence, you are kindly requested to give your response by selecting (circling) your answer from the given alternative choice or describing your opinion. Please be informed that your response is kept in confidential and you are not required to write your name. I would like to thank you for your cooperation.

Appendix I: Background information about the respondents

Instruction: In order to answer the following questions, put a right sign (√) in the boxes that located in front of your choice.

1. Gender :(A) Female□ (B) Male □

2. Age :(A)<20□ (B)16–30□ (C)31–45 □(D)>45□

3. Educational level: A) No formal education□ B) 1-4 grade complete□ C) 5-8 grades complete □ D) 9-12 grades complete □ E) Certificate □ F) diploma □

G) First degree□ H) Second degree and above□

4. Name of your kebele _____

Please read each of the following statements about urban rodents very carefully and decide whether you. Strongly agree (5) Agree (4) undecided (3), disagree (2), strongly disagree (1) mark in the appropriate box to indicate your opinion. The percentages presented relate to valid cases; the number of missing cases is shown below each statement.

Appendix I: Questionnaire prepared to assess residents' perception about urban rodent pests in Jimma town

No	Statements	Rating scales				
		5	4	3	2	1
5.1	People can catch diseases from mice					
5.2	People can catch diseases from rats					
5.3	It is easy to get rid of rodent					
5.4	If my neighbor has rat I will get rat too					
5.5	Rodents are more likely to live in dirty houses					

Residents' source of information about urban rodents

No	Variables	Valid	yes	no
1	What are the sources of information about rodents	Textbooks-		
		Health care workers		
		Total		
2	Respondents seeing a rodent in their household	In the last 24 hours		
		Over the past month		
		Never		
		Total		
3	Rodents move freely in my house	Yes		
		No		
		Total		

4	Rodents often seen crossing between houses	Yes		
		No-		
		Total		

Questionnaire prepared to assess about waste management practices of residents

No	Variables	Valid	yes	no
1	How often do you clean your house?	Every day		
		With two days interval		
		With three days interval		
		With one week interval		
		Total		
2	How often you remove accumulated garbage?	Twice a week		
		Weekly		
		Monthly		
		Daily		
		Total		
3	How many solid waste storage materials do you use to store solid wastes produced in your dwelling?	2		
		3		
		5		
		1		
		Total		
4	What type of solid waste storage material do you use in your house to store solid waste produced from your dwelling?	Sack		
		Basket-		
		Metal container		
		Plastic container (‘festal’		

APPENDIX II

Respondents' knowledge about the contributing factors for abundance of rodent pests

Good house management and clean environment of the house on the abundance of rodent pests.

Rating scales 5 strongly agree 4 agree 3 undecided 2 dis agree 1 strongly disagree

No	Statements	Rating scale
2.1	The cleanness of the house environment can minimize the abundance of rodent pests.	**5 4 3 2 1**
2.2	The good house management can minimize the abundance of rodent pests.	
2.3	The good structure of the walls of the house can reduce the abundance of rodent pests.	
2.4	Avoiding proximity of neighboring houses that might reduce rodent pest entry	
2.5	Housing quality and location minimize abundance of rodent pests	

Participants' knowledge about the bad house structure, management

and unclean environment of the house on the abundance of rodent pests

Rating scales5 strongly agree 4 agree 3 undecided 2 disagree 1 strongly disagree

No	Statements	Rating scale
3.1	The dirtiness of the house environment can increase the rodent pests	5 4 3 2 1
3.2	The poor house management can increase the abundance of rodent pests.	
3.3	Housing structural defects allowed for entry of rodent pest	
3.4	High housing density facilitated the movement of rodent pests between houses	
3.5	Proximity of the houses to dumping sites and refuse bins facilitate the diversity of rodent pests	

APPENDIX III strategies adopted by respondents' about urban rodent control

No	Items	Yes	No
7.1	Use live trap and snap trap only		
7.2	Environmental hygiene		
7.3	Use live trap only		
7.4	Use poison only		
7.5	Block all rat hideouts		
7.6	Store grains, food items in containers with cover		
7.7	Keep pets in the house		
7.8	Periodic fumigation		
7.9	Use poison and snap trap		

Interview Questions prepared for residents of selected kebeles of Jimma town.

Part one: Background information about the respondents

1. Job title in your department _____
2. Employment condition; A) Permanent □B) contract □
3. Educational level; A) No formal education□ B) 1-4 grade complete□ C) 5-8 grades complete□ D) 9-12 grades complete□ E) Certificate □ G) diploma □H) First degree I) □ Second degree and above□
4. Work experience_____.
5. Kebele _____

Part two: Structured questions prepared to assess residents' attitude about urban rodents in Jimma town.

1. How do you perceive residents' attitude about urban rodents in Jimma town?
2. How housing quality and location contributing factor for rodent pest abundance?
3. Do your collection, transportation and disposal service cover all parts of the town? If it not Covered, please specify the major reasons?
4. Do you think residents of Jimma have clear and adequate awareness about solid waste? Management systems?
5. What do you think should be done to improve the situation of environmental solid waste? Management system of the town to alleviate rodent impacts in general?

FGDs Questions prepared for sample selected kebeles respondents of Jimma Town.

Name of the kebeles_____

1. To what extent residents' awareness about urban rodents in your kebele?
2. In your opinion do the rodents cause any damage to the infrastructure of the building?
3. What is the condition of households' solid waste management practices in Jimma town?
4. What are the strategies used to control the impacts of urban rodents by residents of selected kebeles of Jimma town?

Annex 1 Average body measurements of rodent and insectivore pests

Species	Seasons	Number	Body weight(g)	Head body length(cm)	Tail length(cm)	Hind foot(cm	Ear length(cm)
R.rattus	Dry	40	47.6	17.2	19.5	2.6	2.5
	Wet	36	50.6	16.1	18.7	2.7	2.4
M.musculus	Dry	36	29.2	13.7	11.3	2.3	2.2
	Wet	30	30.2	14.5	13.0	2.4	2.3
C.flavescens	Dry	4	10.00	7.5	5.6	2.1	1.2
	Wet	3	9.5	8.00	6.3	2.00	1.3
C.fumosa	Dry	7	11.0	7.00	5.4	2.1	1.2
	Wet	6	10.00	7.7	5.00	2.00	1.2

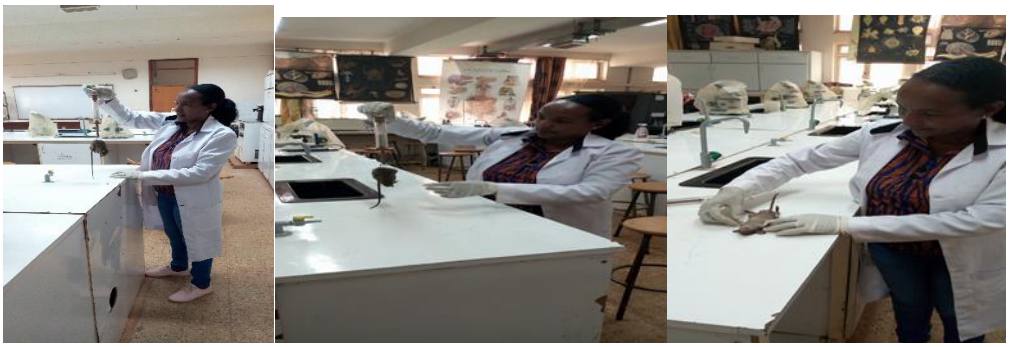

Plate 1.Body measurements conducted in zoological laboratory of Jimma University

Plate 2.Interview with resident conducted.

Figure 6.Solid wastes accumulated near resident house