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DAMAGE CAUSED BY LARGE MAMMALS IN WONJI-SHOA SUGARCANE PLANTATION, CENTRAL ETHIOPIA.

by

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ABSTRACT

The goal of this research was to identify large mammals that cause damage to sugarcane plantation and to determine the extent of the damage; this goal was achieved. The study on the damage caused by large mammals in Wonji-Shoa Sugarcane Plantation was carried out from August 2006 to March 2007. Three sample areas were randomly selected in the sugarcane plantation to collect data on sugarcane damage and faecal droppings of the animals. Strip line transect method was used to estimate hippopotamus population and total count method was used to estimate warthog and grivet monkey populations. Data collected on population estimation and faecal droppings were analysed using descriptive statistic chi-square and for damage assessment T-test was used. There was seasonal variation in the population of the three animals in the area. The estimated hippopotamus population was 129 and 99 during the wet and dry seasons, which was significantly different ($\chi^2 = 3.947$, df =1, P < 0.05). The estimated warthog population was 180 and 140 during the wet and dry seasons, which was significantly different ($\chi^2 = 5.000$, df = 1, P < 0.05). The estimated grivet monkey population was estimated 882 and 630 during the wet and dry seasons, which was significantly different ($\chi^2 =$ 42.00, df = 1, P < 0.01). More number of individuals were recorded during the wet season. The grivet monkey population was most abundant and the hippopotamus population was least abundant in the area. The sugarcane damage caused by hippopotamus was 2745 and 3089 stalk per ha during the wet and dry seasons which was significantly different (t = 16.96, df = 1, P < 0.05). Damage caused by warthog was 3988 and 4025 stalk per ha which was significantly different (t = 216.57, df = 1, P < 0.05). The sugarcane damage by grivet monkey was 3148 and 3590 stalk per ha during the wet and dry seasons which was significantly different (t = 15.244, df = 1, P < 0.05). Sugarcane damage increased during the dry season. Warthog caused more damage than hippopotamus and grivet monkey; hippopotamus caused least damage.

1. INTRODUCTION AND LITERATURE REVIEW

1.1 INTRODUCTION

Ethiopia is one of the most physically and biologically diverse countries of the world (Leykun Abune, 2000). It comprises highland massive surrounded by arid lowlands. It contains various wildlife and wildlife habitats ranging from 110 meters below sea level at Afar depression to over 4,500 meters at Ras Dejen (Shibru Tedla, 1995). Most highlands harbor many endemic plants and animals. They have fewer species diversity than the lowlands. The main reason for the presence of diverse wildlife and large number of endemic species is the rugged topography. This helped to create isolated and varied ecological conditions (Yalden, 1983).

Ethiopia consists of 861 species of birds, 284 species of mammals, 201 species of reptiles, 63 species of amphibians and 150 species of fish (Hillman, 1993). Of these 31 mammals, 16 birds, 24 amphibians, 9 reptiles and 4 fish are considered to be endemic (Hillman, 1993). These species of animals are not evenly distributed in Ethiopia. Large mammalian species are usually found in and around the arid southern part of the country (Hillman, 1986).

For many years, the natural habitats of the country have been altered because of human. Most of the highlands and some of the lowlands have been modified into agricultural and pastoral land. This has led to encroachment into wildlife habitats. The constriction of wildlife habitats resulted in severe competitions for natural resources between wild animals and the local communities. This in turn resulted in wildlife-human conflict (Yalden and Largen, 1992).

As in other parts of the world, in Ethiopia, large herbivore mammals cause damage to agricultural crops and plantations. The extent of damage varies depending on the species of the pest mammal in different parts of the country (Kingdon, 1971). There are wide varieties of pest mammalian species such as hippopotamus, warthog, baboons, monkeys, gazelles, bush-bucks and rodents. These mammals cause serious damage to agricultural crops in different parts of the country. Wonji-Shoa Sugarcane Plantation is among those areas affected by these pest mammals in Ethiopia. This has recently been witnessed by Serekebirhan Takele (2006) on studies on rodent damage in Wonji-Shoa Sugarcane Plantation.

These mammals largely use sugarcane as their source of food. This, however, results in the destruction and reduction of the sugarcane yield per unit area, increase cost of production and human labor (Wonji Shoa Sugarcane Plantation Working Manual, 2004). The current study is aimed at collecting data on the extent of sugarcane damage caused by hippopotamus, warthog and grivet monkey.

1.2 Literature review

Human wildlife conflicts occur worldwide and are not confined only to developing world. The numerous cases reported from countries all over the world demonstrate the severity of human wildlife conflict and suggest an in-depth analysis to understand the problem and support the conservation prospects of threatened and potentially endangered species (Hill, 2000).

What is the exact definition of human wildlife conflict? When and where does it usually occur? It occurs when wildlife's requirements overlap with those of human populations, incurring expenses/damages to residents and wild animals. Direct contact with wildlife occurs in both urban and rural areas, but it is generally more common inside and around protected areas, where the wildlife population density is high and animals often stray into adjacent cultivated fields or grazing areas (Ogada et al., 2003).

Human wildlife conflict is intense in the tropics and in developing countries where livestock raring and agriculture are important parts of rural people's livelihoods and income (Else, 1991). In these countries competition between local communities and wild animals, for the use of natural resources, is particularly intense and direct, making resident human populations very vulnerable. The relative impact of wildlife damage on farm production and house hold income varies greatly according to the amount of land owned and people's economic dependence on rural activities (Messmer, 2000). Human wildlife conflicts undermine human welfare, health and safety and have economic and social costs. Humans can be economically affected through destruction and damage to property and infrastructure, for example, agricultural crops, grain stores, water installation, fencing and pipes. Negative social impacts include missed school and work, in looking after additional labor costs, loss of sleep and fear (Hoare, 1992).

A set of global trends has contributed to the escalation of human wildlife conflicts world-wide. These can be due to human population growth, land use transformation, species habitat loss, degradation and fragmentation, growing interest in ecotourism and increasing access to nature reserves, increasing livestock populations and competitive exclusion of wild herbivores, abundance and distribution of wild prey, increasing wildlife population as a result of conservation program (Hill, 2000). Demographic and social changes place more people in direct contact with wildlife; as human populations grow, settlements expand into and around protected areas, as well as in urban and sub-urban areas.

In Africa, human population growth has led to encroachment into wildlife habitat constriction leaving species into marginal habitat patches and

direct competition with local communities (Siex and Struhsaker, 1999). The transformation of forests, savannah and other ecosystems into agrarian areas or urban agglomerates is a consequence of the increasing demand for land, food production, energy and raw materials. In Kenya, in many areas with abundant wildlife, conflict is intensified by land use fragmentation and the development of small-scale farming (Hill, 2000).
In the Indian state of Gujarat, intense and escalating conflicts are due to the rapid and extensive change in land use associated with habitat changes (Vijayan and Pati, 2002). Species habitat loss, degradation and fragmentation are also interconnected with population growth and land use change. Almost all wild animals are potential competitors or threats directly competing with humans for resources such as food or water (Eltringham, 1979). Crop-raiding animals may cause substantial damage to agricultural crops, and this has always been a major issue of contention throughout the world. Crop-raiding can be simply defined as wild animals moving from their natural habitat onto agricultural land to feed on the produce that humans grow for their own consumption (Hill, 2000).

Crop damage is a widespread and common problem across the sub-Saharan region (Maples et al., 1976). Crop damage in Africa by potentially life threatening species such as hippopotamus, buffalo, rhino, warthog, and elephant results in unique dilemma (Naughton-Treves, 1998). These animals can be extremely dangerous to hunt by 'traditional' methods (snares and spears) and farmers can also be killed trying to defend their crops from them. These species are generally perceived by people as property of the state. The state institutions responsible for protected areas are, therefore, considered responsible for these animals, and the institutions are generally ill-equipped to overcome the problem and are blamed for losses to crops and property. Rural farmers for the most part attend their crops. The problem escalates when an animal, wounded by snares or spears, ultimately kills a person (Monaghan and Wood-Gush, 1990). Wild animals exert significant influences on food production systems which may be positive or negative. Positive influences include the role of wild animals as seed dispersal and pollination agents as well as use of wild animal's droppings as fertilizers. Many species of birds and mammals such as bats, monkeys, baboons and squirrels are known to spread fruit trees during feeding (Elias, 1988).

The activities of the pest may result in direct crop losses as a result of feeding and contamination or indirect losses which may occur through damage to production systems and equipment (Elliot, 1979; Taylor, 1984; Natiamoa-Baidu, 1987; Elias, 1988). A wide range of other mammalian species including bats, baboons, monkeys and elephants can also cause significant damage locally to food crops such as banana, cocoa, and oil plantations. Bell (1984) reported that in the Lilongwe area of Malawi, crop damage was mainly caused by elephants, bush-pigs, baboons, grivet monkeys, eland and kudu, together with elephants and bush-pigs accounting about 80% of the total damage. In Zambia, the main wild animal pests are monkeys, warthogs, baboons, elephants, and hippopotamus. Wildlife damage to agriculture has increased over the last 30 years (Decker, 1991; Jonker and Conover, 1998). There are several reasons why crop damage may be on the increase. Some of the reasons are the following:

In recent decades, there has been a large move towards the intensification of agriculture, and the resulting large monoculture can be very attractive to animals (Balinga, 1977). These extensive areas of cultivation are high quality patches that herbivores cannot miss or resist. Some animals are naturally pre-adapted to take advantage of these opportunities, for instance, cereal crops are a target for birds that are primarily seed eaters, and root vegetables are a prime target for species of porcupine and pigs that are specialist tuber diggers. In addition, monocultures (example wheat, barley, teff and sorghum) are often unsuitable habitats for predators that would otherwise help reduce the populations of crop raiding species, thereby exacerbating the problem even further (Elliot, 1979).

Although there is a general concern over declining wildlife populations, particularly in tropical ecosystems, some species may actually be increasing in numbers. For example, increasing reports of crop raiding by elephants in Africa may reflect the recovery of population numbers since the CITES ban on ivory trade and the subsequent decline in poaching (Taylor, 1984).

More people means, more cultivated land, and hence a greater interface between people and wildlife. The world population is predicted to grow by over 50% in the next fifty years, from six billion in 2000 to over nine billion in 2050. Most of this increase is expected to take place in the least developed countries of Africa, Asia and Latin America (Hill, 2000). As the human population keeps expanding, there is an increasing demand for land for agriculture, and natural resources for industry, leading to increased contact opportunities for wildlife and people, resulting in conflict (Naughton- Treves, 1998).

The increasing demand for land to be cultivated means that in many areas use marginal land leading to farming right up to the boundary of wilderness and protected areas (Riney, 1964). Pest species are likely to flourish along the edges of natural habitat and agricultural lands, where they can eat both the food available in undisturbed habitats and the crops growing in the adjoining farmland (Taylor, 1984).

As wilderness gets converted to agricultural use, protected areas such as national parks, reserves, and hunting blocks, rapidly become "islands" in a sea of farmland. Wildlife populations are thus effectively cut-off from populations in other patches of natural habitat (Riney, 1970). These fragmented areas differ from the original, undisturbed ranges in two ways. First, the edge size in relation to the fragment size is high, and second, the center of each fragment is closer to an edge. As a consequence, the probability of wildlife-human contact increases resulting in the likelihood of conflicts such as crop raiding, because potential crop raiders have to travel shorter distances to access crops (Hill, 2000).

Industrialization has a major influence in the development of human culture. The young people from the rural areas achieve a better lifestyle in urban areas. This causes shortage of man power in the rural areas, like guarding farming fields (Richter, 1970). Children who were supposed to guard their parent's fields against crop raiding animals would not attend school. After completing their studies many of them will not return to their original places instead find employment in other towns and cities (Makombe, 1993).

These factors which have been facilitating crop damage are most important in the developing world at the present time. A study around the Budongo Forest Reserve in Uganda found that the cost of crop raiding and guarding varied from 96-519 dollars per household per year (Hill, 1997). This is a huge amount if we consider the average local salaries in this area, 25-30 dollars per month. In certain cases the impacts of crop raiders can be devastating, as the whole crop may be destroyed in one night (Reul, 1979). With the mitigation of crop raiding losses, compensation is rarely available, and where it is present, it often implies a lengthy procedure with the claim going through several layers of bureaucracy. Crop raiding can make already secured livelihoods even more marginal in economic terms (Taylor, 1984).

In the present study area, there are varieties of pest mammals, such as hippopotamus, warthog, grivet monkey, baboons, gazelles, bushbucks, and rodents. But the current study focuses only on the three of the large mammals namely; hippopotamus, warthog, and grivet monkey. General information, habitat, feeding habits, social organization, and reproduction of these crop raiding animals is presented below.

1.2.1 Hippopotamus

Hippopotamus *(Hippopotamus amphibus)* is a large herbivorous African mammal (Corbet, 1969). Hippopotamus is a common name for the two species of artiodactyls mammals that constitute the family Hippotamidae, found only in Africa, one is common hippopotamus and the other is pygmy hippopotamus. Hippopotamuses are called river horses, and are heavy bodied, short legged, short-tailed animals, resembling pigs more than horses (Solomon Gebreyohanis, 2003). The body is barrel shaped and the belly hangs low, just above the ground.

Hippos are gregarious, living in groups of up to 40 animals called a pod, herd, school or bloat (Corbet, 1969). A hippo's life span ranges from 40 to 50 years. At average, hippos are 3.5 m tall at the shoulder, and weigh from 1500 kg to 3200 kg. Even though they are bulky animals, hippopotamuses can run faster than a human being on land. The actual running speed varies from 30 km/hr to 48 km/hr. The eyes, ears, and nostrils of the hippo are placed high on the roof of the skull. This allows them to spend most of the day with the majority of their body submerged in the waters of tropical rivers to stay cool and prevent sunburn. For additional protection from the sun, their skin secretes a natural sunscreen substance known as “blood sweat”. This secretion initially colorless turns red orange within minutes, eventually becoming brown. The red pigment inhibits the growth of disease-causing bacteria. The light absorption of both pigments peaks in the ultraviolet range, creating a sunscreen effect (Saikawa, 2004).

Hippos occur in the rivers and lakes in sub-Saharan Africa, including Uganda, Sudan, Kenya, Northern Democratic Republic of Congo, Ethiopia, and West to Gambia, as well as in southern Africa Botswana, Republic of South Africa, Zambia, and Zimbabwe (Astey, 1991; Ritchie, 1930).

The common hippopotamuses are highly territorial; a male hippo often marks his territory along a riverbank to draw in a harem of females, while defending it against other males. Male hippos challenge one another with threatening gapes (Okello et al., 2005). Since their habitat is often encroached by farmers and tourists and because they are territorial, the hippopotamus is one of the most dangerous animals in Africa. They are said to account for more human deaths than any other African mammals (Kingdon, 1982). The hippo does not hunt humans, but defends its own territory vigorously. Hippos are usually found in shallow waters, and rarely come out of that depth. Most hippos that look as though they are floating are standing or lying on the bottom.
They come on land to feed, mostly at night, consuming as much as 50 kg of vegetation per day (Fig. 1).

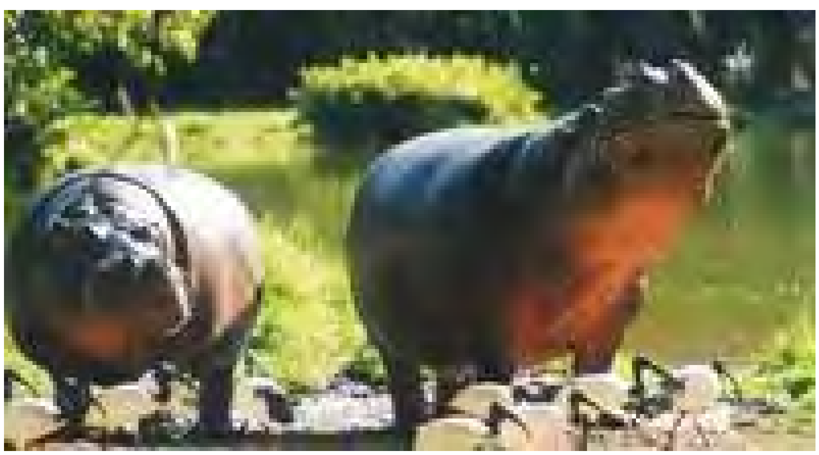

Figure 1. Hippopotamuses on land.
Source: Animal diversity web (online) accessed at http://animal diversity Organization).

Adult hippos are not generally buoyant. When in deep water they usually, propel themselves by leaps, pushing off from the bottom. They move at the speed up to 8 km/hr in water. Young hippos are buoyant (Hillman, 1982). Adult males compete for control of a herd and the territory it occupies between bulls may last several hours. The hippos herd is basically a matriarchy consists of 10-30 mothers and their young. Generally, young are born after a gestation period of 227-250 days. Mating and birth usually is under water and the calf can be nursed under water. The cow bears one young at a time and fights ferociously if the calf is attacked. Baby hippos weigh between 25 to 45 kg. They must swim immediately to the surface in order to take their first breath (Errington, 1946). Adult hippos typically resurface to breath for about 5 minutes (Fig. 2). The young have to breathe every 2-3 minutes. Hippos have been documented staying submerged for up to thirty minutes (Eltringham, 1996).

Figure 2. Hippopotamus resurface to breath.

Source: Animal diversity web (online) accessed at http://animal diversity Organization).

Bulls have a loud roar that can be heard over a great distance. They also have a cattle-like bellow accompanied by a wide open mouth that is used as a threat (Macdonald, 1985). Hippos are hunted extensively for their highly prized flesh, abundant fat, the superior quality of their tusk and for hide. They are hunted for sport and killed by farmers for the extensive damage they cause to crops. It has become rare in much of its range, but there are still large populations in the upper Nile Valley of East Africa (Kingdon, 1982).

1.2.2 Warthog

The warthog is known as the naked swine of the savannah (Spook, 2004). Warthogs get their name from the large warts found on their head (Kleiman et al., 2004). It is slimmer than other hogs and comparatively long limbs. The two extant species include the common warthog (*Phacochoerus africanus*) and the desert warthog *(Phacochoerus aethiopicus*).

Males are typically larger than females. Common warthogs weigh 50 to 150 kg with females being 15 to 20 percent lighter than males (Cumming, 1975). The tusks are small in females but large in males (Figs. 3 and 4). Common warthogs have large upper tusks that are 255 to 635 mm long in males and 152 to 255 mm in females (Vercamen and Mason, 1993). Warthogs have three pairs of facial warts, composed of cartilaginous connective tissue (Estes and Cumming, 1882).

The head is large with a mane that extends down the spine to the middle of the back. There is sparse hair covering the body, they are found in a variety of colors from light red to brown and gray to mostly black (Mason, 1982). Common warthogs have two upper and four to six incisors on both sides of the jaw in contrast to cape warthogs, which lack incisors (Creel, 2005). They have large prominent tusks.

Warthogs can tolerate higher than normal body temperatures, which is believed to be due to their ability to conserve moisture inside their body. They have also been known to cope with low temperature. Behavioral strategies, such as wallowing and huddling together, are used to help them tolerate high and low temperatures, respectively (Mason, 1990).

The life span of warthogs is about 18 years. Warthogs have a heavy age-constant number of deaths for most of their lives. Warthogs differ from other species in their high reproductive rate. Warthogs are polyovular, with annual litters of 2-7 offspring (Kleiman et al., 2004).

Warthogs prefer moist habitats with plentiful vegetation and tend to avoid drier, open areas (Figs. 3 and 4).

Figure 3. Female warthog in grassland habitat.

Figure 4. Male warthog in grassland habitat.

Source: http://www.bushveld.Co.za/warthog.htm accessed on 23/01/2007

Warthogs are true savanna dwellers, which avoid dense cover and forest but depend on burrows to escape predators and extreme temperatures, especially in infancy (Mason, 1985). They also occur in Bale Mountains above 3000 m (Hillman, 1986). Warthogs occur outside forested areas in Africa from Mauritania to Ethiopia and south to Namibia and eastern South Africa (Grubb, 1993). Warthogs are mainly diurnal animals and sleep in self-excavated burrows or in heavy thickets of vegetation during the day time (Fig. 5). Most of the holes that warthogs use for sleeping and protection were excavated by aardvark (Spook, 2004). Warthogs are omnivorous, consuming roots, bulbs, fungi, fruits, eggs, invertebrates, birds, small mammals and carrion. They drink water regularly and in hot, dry weather, they use wallows daily. However, they are the only pigs able to live in areas without water for several days of the year (Sandell and Liberg, 1992).

Figure 5. Warthog's best habitat (burrow in Wonji-Shoa Sugarcane Plantation fields) (Photo: Mesele, 2006).

Common warthogs do not exhibit territorial behavior. Warthogs share resting, feeding, drinking and wallowing sites (Cumming, 1975). Warthogs are seasonal breeders. They mate as rains end and burrowing 160 to 170 days later as rainy season begins. Both sexes are fertile by 18 or 19 months, but very few males breed before four years old (Mason, 1982).

Young isolate to burrow and stay underground nurturing hairless piglets for the first week after the young are born. The size of the litter ranges from one to six, but three to four piglets are common (Mason, 1986). Associated mother warthogs suckle one another young (Jensen et al., 1998).

Warthogs would rather run than fight, but they can be very fierce if forced to fight (Sinclair, 1985). They are known for ferociously defending their family. Warthogs are slower and have less endurance than most savanna ungulates; therefore, burrows are essential to their safety when being chased. Warthogs have poor eyesight (Cotgreave, 1998). Some of their typical predators include cheetahs, wild dogs, and spotted hyena. Burrows provide the much needed protection particularly at night (Leuthold and Leuthold, 1975).

1.2.3 Grivet monkey

The grivet monkey *(Cercopithecus aethiops*) is a medium to large African monkey, head and body length is 40-60 cm, and its weight ranges from 5-8 kg. They also have a white band on their forehead, which makes them easily identifiable (Spinage, 1962).

The female grivet monkey is smaller than the male. They are arboreal and roam around during the day in large troops (Jurgen, 1955).
Grivet monkeys congregate around acacia trees. They are common in woodland habitats along the shores of lakes and streams. They belong to

a group of four or five closely related species in the genus C*erocopithecus,* throughout much of sub-saharan Africa (Phllis, 1969).

Grivet monkeys are found in savanna woodlands and along river courses (Fig. 6). They occur in Botswana, Namibia, Zimbabwe, Swaziland, Mozambique, South Africa and Ethiopia (Kingdon, 1997). They are omnivorous but feed mainly on plant material, which includes fruits, seeds, flowers, buds, roots, bark and gum (George, 1975). They also eat insects (mainly termites and grasshoppers), lizards, eggs of birds and occasionally bird hatchlings. Grivet monkeys have complex social organizations. Grivet monkeys are pests throughout their sub-Saharan range; where they not only raid farmers' crops but also boldly steal food from hotel residents (David, 1985).

Figure 6. Grivet monkey (male) in the natural habitat.
Source: http://www wildlife pictures (online). Com/monkey pictures.

Grivet monkeys produce one young at a time which is born after a gestation period of eleven months (Moss, 1979). The young are unaffected by the social hierarchy up to the age of 18 months. Females have their first young at roughly three years old. Grivet monkeys have a highly developed system of communication. They are one of the most successful animals in Africa due to their group structures and organization. They spend a lot of time on the ground, but they sleep on trees. They live in troops of 15 to 60 members (Spinage, 1972).

They are preyed upon by leopards, eagles, crocodiles and sometimes, larger baboons. Man also affects the population by capturing and using for medical research (Moss, 1979).

1.2.4 Damage management

In some cases, a pest animal is legally protected or simply can not be repelled from fields (See below). In some countries, a multifaceted approach is adopted where farmers are compensated for their losses. Attempts are made to repel pest species and the communities are sensitized on the values of living with this animal (Blankenship et al., 1990). Thus, these points highlight not only the technical problems with controlling predation, but also the social costs as well. Crop damage is a widespread and common problem across the sub-Saharan region. There are a number of problems that compound the effects of crop loss upon rural farmers besides the direct impact on their livelihood. Controlling damage by wildlife has been the subject of research by biologists for decades. Wildlife managers are often confronted with a situation in which a resource, either naturally occurring or farmed, is consumed by wildlife. Essentially to 'control' the problem caused by wildlife is to reduce the impact of wild animal on the resource within tolerable limits (Monaghan and Wood-Gush, 1990). Wildlife damage control is, essentially, the art of trying to reduce the impact of a particular species natural habitats on an item which human's value. Certain sectors of a society may want a species to be preserved, while communities affected by the damage want them eliminated. Therefore, controlling pests is not merely a technical problem, but a social and ethical dilemma as well (Naughton-Treves, 1996).

Larger animals are of increasing concern and considerable research has recently focused on reducing the losses incurred. Wild ungulates damage thousands of hectares of trees in plantations and forage on commercial crops. Crop damage in Africa, by potentially, life threatening species such as hippos, buffalo, rhinos and elephants possess particularly a difficult problem. These animals can be extremely dangerous to hunt by 'traditional' methods and farmers can be killed trying to defend their crops (Stander, 1990).

A wide range of different management tools has been developed worldwide to address human wildlife conflict, but most of these are species specific and are not widely or easily accessible. They are also targeted towards different taxonomic groups (Hoare, 2001). Prevention of many conflicts between animals and people can be achieved by excluding unwanted animals from a resource or decreasing its attractiveness to the animals (Hunt, 1984). The technique selected to limit crop damage is often specific to the species involved. Thus, the first step in developing a strategy for controlling pests is a broad understanding of the ecology of the target species (Buckley, 1985). Some of the basic methods to control wildlife from crop damage are discussed in the following paragraphs.

1.2.4.1 Methods to control damage

Lethal controls are usually used for animals that are common, such as, small carnivores, rodents and some bird species. Methods include using a variety of traps and snares, poisoning a caracas and 'baiting' response to crop-raiding such as elephants. Warthog, hippos, monkeys, deer, and others are surveyed to assess the damage and then attempt to minimize the problem. Shooting crop raiding wild animals at night while raiding was the best way to scare others. The meat is then given to the people to appease their anger and compensate for crop losses (Thomas, 1991). While this method is still practiced to some degree throughout much of the crop-raiding animals range, most wildlife managers feel that it is temporary and is a drain on a valuable resource. Discussions with control officers across the southern African region indicate that shooting crop-raiding animals while raiding can have some deterrent effect on other raiders in certain situations, but the effect is temporary (Ajayi, 1973).

Crop raiding is not a new phenomenon. Farmers have evolved resourceful strategies to fight back against the animals responsible for damaging their crops (Butler, 1995). The methods that are employed by an individual farmer are deeply influenced by the resources at his disposal. In developed countries, farmers have considerable levels of capital and expertise to combat crop raiding. In developing countries such as Tanzania, Kenya and Ethiopia farmers have limited income and little access to technology. A range of methods have evolved in such countries, relying on simple, manpower based techniques to tackle crop raiders (Langbauer et al., 1991).

The most common method to prevent crop raiding is to simply **chase the animals away** from the crops (Taylor, 1982). Once animals are spotted in a farm, people will run at them, yelling, banging drums and throwing objects to chase them away. This can be effective at times, but often the animals return to crops as soon as the people disappear. With animals such as elephants, hippos and warthog, this can be a hazardous method, as the culprit instead of fleeing may attack and even kill the chaser.

An extension of the chasing method is to **permanently guard** the fields. Guarding is undertaken throughout the year, but often increases in the harvest season when the risk from crop raiding is at its greatest. Children and women are often given the task of guarding their family's fields (Hill, 2000). A study on Budongo Forest Reserve in Uganda showed that children and women are responsible for 30% and 34% of the guarding, respectively (Hawthorne, 1980). In some areas, farmers employ guards to protect their fields, while others use dogs to frighten and chase away crop raiders. Co-operation between farmers often means that a guard will also help protect neighboring fields. Guarding can be costly in terms of time spent. It is almost impossible for farmers to guard their fields all the time. It is inevitable that some crop raiding will still occur (Seidenstiker, 1984). Several methods are used to try and prevent crop raiding by scaring animals away through the use of brightly colored objects, and loud noises (Western & Lindsay, 1984).

Strange unusual smells are sometimes used in the belief that they will ward off wild animals. Some farmers believe that burning sheep's dung around the edge of fields will help keep elephants, hippos and warthogs away, while others place scented soap around their fields to mimic the smell of humans to scare animals away. There is some evidence that these techniques can be effective against the more timid animals, but bolder crop raiders appear no to be bothered (Bullard, 1985).

Hot pepper spray is used in an effort to keep animals away from farmer's fields and thus prevent crop raiding. **Fencing** is also used to prevent crop raiding. Most fencing is constructed from local materials and is of a simple design (Hoare, 1992). As a result, fences are not very effective because many animals can get through or over it (monkeys) while others simply destroy it (elephants, warthogs, hippopotamus). In addition to fences constructed by an individual farmer, there are also large-scale fences funded and constructed by governments. These are often electrified and have been used in an attempt to prevent crop raiding (Elliot, 1979). Electric fences have also been successful in protecting small farms or cash crops. However, the materials, installation and maintenance costs make these methods impractical for large-scale applications in poorer developing countries unless funded by international aid agencies. Electric fencing can be considered as a more sophisticated solution. It is more durable, due to the reduced physical pressure from animals and it deters a wide range of species. The disadvantage is that fencing can also cause huge ecological problems, by cutting off the traditional migration routes used by many species and by preventing widely scattered species from finding reproductive mates (Hoare, 1992).

Farmers have traditionally mitigated some of the loss from crop damage by **hunting wildlife in their fields**. Wildlife protection laws prohibit local people from hunting wild animals (Frank, 2003). These laws are put in place to tackle poaching and are enforced by local and wildlife authorities, with offenders often facing penalties (Elias, 1988).

Farmers may place **traps or snares** in their fields to catch animals that raid their crops. Alternatively, they may be paced inside wildlife habitat in an attempt to reduce the numbers. Traditionally, these captured animals are killed and used for food. In recent years, some species, especially primates have been kept alive to be sold either as pets or for experimental use in medicinal and pharmacological research (Infield, 1988). To kill crop raiding animals poisoned baits are placed in and around fields. This method may work in the short-term. Many animals, however, show neophobia, for example, rejection of new food stuffs, others learn not to eat poisoned food and some, including primates, may not eat any food that has an unusual taste (Pitman, 1990). There is also the added risk that livestock and non-target wildlife will consume the bait intended for crop-raiders. So, a farmer has to be very careful and selective where to deploy the poison bait (Young, 1975).

1.3. Objectives of the Study

1.3.1. General Objective

- The objective of this research is to identify and estimate large mammals that cause damage and determine the extent of damage in Wonji-Shoa Sugarcane Plantation.

1.3.2. Specific Objectives

- To study the population abundance and seasonal fluctuation of large mammals in the sugarcane plantation area.
- To identify which prominent large mammals cause greater damage to the sugarcane plantation.
- To study and estimate the extent of damage to sugarcane plantation by large mammals.
- To provide feedback to Wonji-Shoa Sugar Factory about the extent of the sugarcane plantation damage for management action.

2. Study area and methods

2.1 Study area

2.1.1 Location

The present study was carried out at Wonji-Shoa Sugarcane Plantation; located at about 110 km southeast of Addis Ababa. It is situated between 18^0 31' N and 39^0 12'E and elevation of 1540 m above sea level (Fig. 7). Furrow irrigation system is used to water a total land area of 7022.24 ha, out of which 1118.67 ha, is owned by seven local cooperative farmer associations. The farmer associations get technical advice and assistance from the factory because they grow and supply sugarcane to the factory.

Availability of sufficient water is essential for growing sugarcane in Wonji area. Hence, an efficient system was developed through the years that comprise irrigation canals with a total length of 300 km, drainage canals 200 km, and numerous small artificial lakes. All these water canals are dependent on Awash River (Wonji-Shoa Sugar Factory Working Manual, 2004).

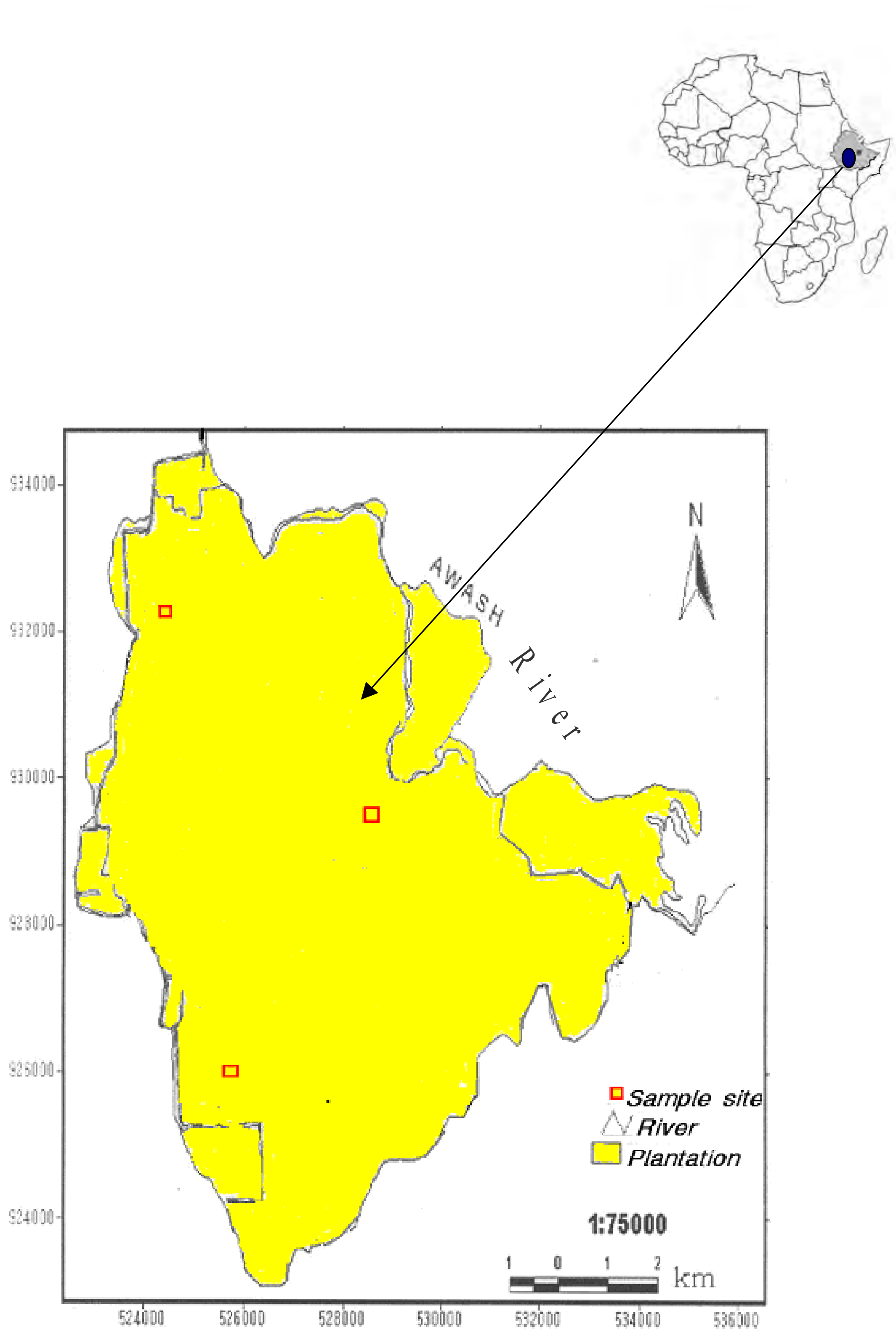

Figure 7. Map of the study area

2.1.2 Climate

The climate of Wonji-Shoa area is tropical with wet and dry seasons. Short rains, March to May merge into the main rainy season from mid-June to mid-September (Fig. 8). The highest rainfall was registered in July and August and minimum in January and December. The annual relative humidity ranges from 34.5 to 63%. The mean monthly temperature minimum range is between 6.9^{0}C and 14.7^{0}C (November) and that of maximum between 23.1^{0}C and 30^{0}C (May) (Fig. 9) (Wonji-Shoa Sugar Factory Working Manual, 2004).

2.1.3 Soil types and Vegetation

Among the many varieties of sugarcane in the world, ten major cane varieties are grown in Wonji sugarcane plantation. These are: B52-298, CO-421, M165/38, NCO-334, N-14, DB414/66, Mex 54/245, B58-230, B59-212, and B41-227. Of these B52-298 is widely grown and forms the dominant variety in the area. The cane plant flourishes in a wide variety of soils, ranging from very heavy clay soils to light clay soils. Soils in the area are locally classified as A1, A2, BA14, and C1. The plantation has flat topography and sugarcane is cultivated as perennial monocrop.

The way to establish a cane field is by planting sets. Seeds are used only for breeding new varieties. But growth of the cane also commences with tillering followed by crop growth, crop maturity and harvest. When crop yield becomes too low, new sets are planted. The crop cycle of the cane can be looked at two stags: the first from the original set planting new set planting and the second from set planting or the previous harvest to the following harvest. The first or complete crop cycle lasts from three to ten years or longer if the crop is well managed. The second is called the harvest or annual cycle and usually lasts from ten to twenty four months (Wonji-Shoa Sugar Factory Working Manual, 2004).

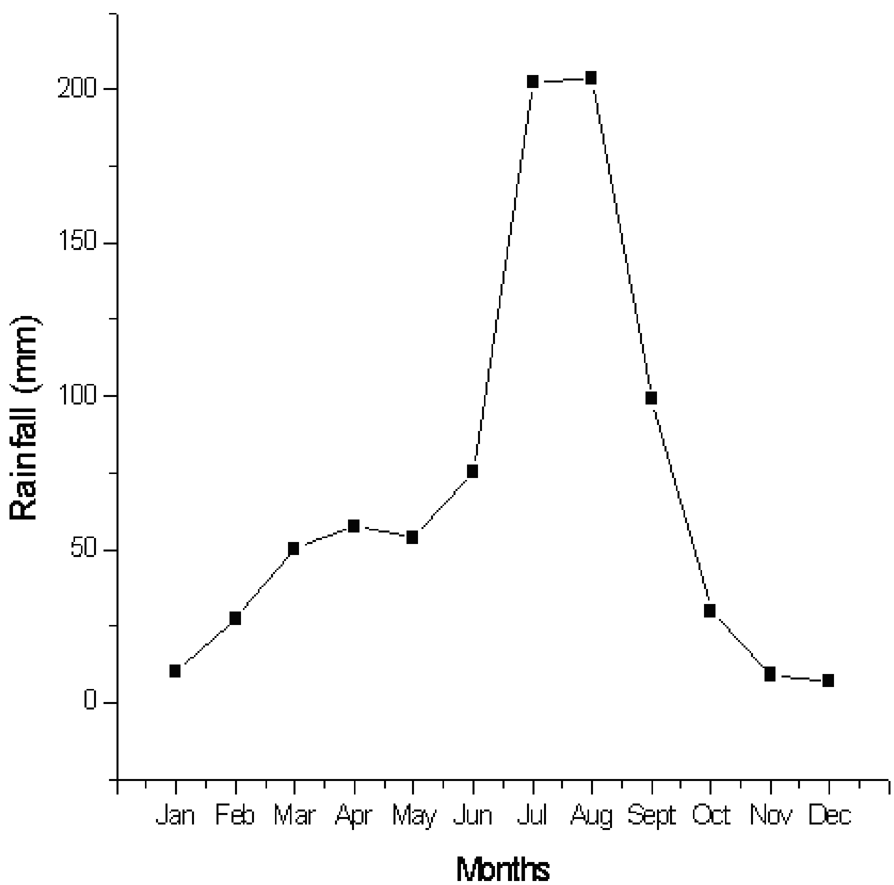

Figure 8. Monthly average rainfall at Wonji area (2000-2006).
Source: Data from metrology of Ethiopia, 2007.

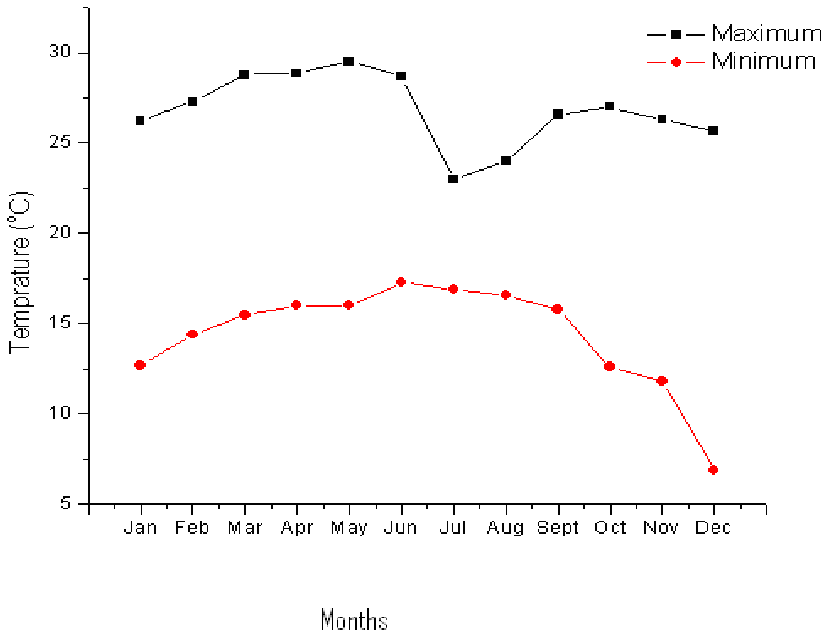

Figure 9. Monthly average maximum and minimum temperature at Wonji area (2000-2006).

Source: Data from metrology of Ethiopia, 2007.

2.2 Methods

2.2.1 Population Estimation

Data on population estimation of hippopotamus, warthog and grivet monkey in Wonji-Shoa Sugarcane Plantation were collected for both the wet and dry seasons. It was carried out twice in the wet season that is from August 2006 to October 2006 and twice in the dry season, from December 2006 to March 2007.

Warthogs usually hide in the sugarcane plantation which grows above two meters and in burrows. Total count method was used to estimate the warthog population. To count the warthog population the plantation area was divided into three counting sites. Nine individuals were employed to count the warthog population. Three individuals were assigned in one counting site, under the supervision of the researcher. The number counted by the nine individuals was added up to get the total warthog population in the study area. To get the density, the number of animals counted was divided by the area of the study area.

To estimate the grivet monkey population, total count was used to avoid biases that may be caused due to the rapid movement of grivet monkeys from one place to the other. To minimize biases, counting in the three sites was carried out simultaneously.

To estimate the hippopotamus population strip line transect was used. Hippopotamuses outside the strip transect were not counted (William, 1996). To estimate the hippopotamus population six strip transect samples were randomly laid across Awash River course. To collect the data, six individuals were employed and each individual was responsible to count the hippopotamuses found within one km length and 900 meters width. To estimate the density of hippopotamus population, the number of hippos counted (n) in the Awash River course and length (l) of the strip km and width (W) of the strip sample 900 m was used.

Thus,

$$D = \frac{n}{2 \times L \times W}$$

D = Density,

n= number of hippos counted

l=Length of strip sample

W = width of the strip sample

The total population of hippopotamus was calculated by multiplying the density of the population with the total area and also counted by direct observation using binocular in the river.

The area of Awash River includes the southeast of the plantation 16 km and northwest of the plantation (14 km) totally 30 km. To get the density of animals the number of animals counted divided by the area of the study area.

2.2.2 Sugarcane damage

Data on the sugarcane plant damage by hippopotamus, warthog and grivet monkey were collected for both wet and dry seasons. Estimation of sugarcane plant damage by the animals was carried out in the following way: the number of plants knocked down or eaten by animals in sampled fields was counted. To estimate sugarcane plant damage by hippopotamus, a sample of 16 fields of sugarcane plantation was randomly taken from the total of 96 fields in the study area. Each field covers about 250,000 m^2 area. The sugarcane plant damaged by hippopotamus was identified as newly growing shoots, or young sugarcane plants. This was identified by repeated observation of the damage and using indirect evidences such as hoof mark observed along with the damaged plants. Eight individuals were employed and each individual was responsible to count the damage in two fields together with the researcher. To get the total damaged plants in the sampled fields, the number of damaged plants counted by the eight individuals was added up. The damaged plants were assessed per ha of the fields.

The sugarcane plants damaged per ha was compared with the actual sugarcane stalk count per ha during the wet and dry seasons. The sugarcane plant damaged by warthog and grivet monkey was estimated like that of the hippopotamus damage but the difference is that the two animals feed on different parts of the sugarcane plant. Warthogs usually feed on roots and rhizomes of different plant species. It also feeds on the root parts of the sugarcane plant. Thus, to estimate the damaged plants, the plants eaten or damaged at the roots were counted.

Grivet monkeys usually chew sugarcane like human beings cutting at the center of the matured sugarcane plant, especially at the nodes. To estimate the damaged plants, the plants eaten or damaged at the middle were counted in the sampled fields.

2.2.3 Faecal and stomach content analyses

Ecological information was obtained from the analysis of faecal deposits following Putman (1984). Faecal samples of hippopotamus and warthog were collected. The faecal droppings were collected from the 16 fields of sugarcane plantation which were sampled in the study area. Faecal droppings of the animals were collected at the intervals of 250 m to make the samples different in sample field. A total of 64 faecal samples of warthogs and 80 faecal samples of hippopotamuses were collected from the sample area. The faecal droppings were dried and washed with distilled water in the laboratory. Then, the samples were microscopically analysed for the presence or absence of sugarcane fragments. Stomach content of a killed warthog was taken and analysed in the laboratory for the presence of sugarcane fragments in the stomach. For the diet analysis of warthog the stomach content was dried and washed with distilled water and then, analysed microscopically.

2.2.4 Sampling design and Data analyses

Based on the topography of Wonji-Shoa Sugarcane Plantation, three sample areas were randomly selected to assess sugarcane damage and collect the faecal droppings of hippopotamus and warthog. To quantify the sugarcane damage, 16 fields were randomly selected in the three sample sites. Each sample area was about 600 hectares, and at an average five km far apart from each other. To estimate the grivet monkey and warthog population, the total area was divided into three counting sites. To estimate the hippopotamus population, six strip line transect samples were laid across the Awash River course. All the data collected were analyzed using SPSS version 13 computer software programs. The estimated populations of hippopotamus, warthog and grivet monkey during the wet and dry seasons were compared using chi-square to determine whether there was significant difference between the wet and dry seasons. For the data gathered using fecal and diet analysis, chi-square was also used to determine whether the sugarcane fragments found in the faecal droppings of hippopotamus and warthog were significant or not between the wet and dry seasons. To assess the significance of sugarcane damage by animals in the study area, a descriptive statistics, T-test was used. This was also used to determine which animal caused more damage than others in the Sugarcane Plantation of Wonji-Shoa.

3. Results

Animals that caused greater damage to sugarcane plant are hippopotamus (*Hippopotamus amphibus*), warthog (*Phacochoerus africanus*) and grivet monkey *(Cercopithecus aethiops*). The result is given in the form of population estimation, faecal and diet analysis and sugarcane damage assessment.

3.1 Population estimation

The estimated population of hippopotamus during the wet and dry seasons was 129 and 99, respectively (Table 1). The population of hippopotamus was significantly differed between wet and dry seasons ($\chi^2 = 3.947$, df = 1, P < 0.05). Males and females comprised 48 and 81 during the wet season, respectively (Table 1). There was significant difference between the male and female population during the wet season ($\chi^2 = 8.442$, df = 1, P < 0.05). Males and females also comprised 33 and 66 during the dry season, respectively (Table 1). There was significant difference between male and the female population during the dry season ($\chi^2 = 11.0$, df = 1, P < 0.05).

The warthog population was 180 and 140 during the wet and dry seasons, respectively (Table 1). The warthog population significantly different between the wet and dry seasons ($\chi^2 = 5.00$, df = 1, P < 0.05). Males and females compared 77 and 103 during the wet season, respectively (Table 1). There was significant difference between the male and female population during the wet season ($\chi^2 = 3.756$, df =1, P < 0.05). Males and females also compared 56 and 84 during the dry season, respectively (Table 1). There was significant difference between the male and female population of warthog during the dry season ($\chi^2 = 5.600$, df = 1, P < 0.05).

The population of grivet monkey during the wet and dry seasons was 882 & 630, respectively (Table 1). The population of grivet monkey during the wet and dry seasons was significantly different (χ^2 = 42.00, df = 1, P < 0.01).

Males and females compared 352 and 530 during the wet season, respectively (Table 1). There was significant difference between the male and female population during the wet season ($\chi^2 = 36.369$, df = 1, P < 0.01). Males and females compared 245 and 385 during the dry season, respectively (Table 1). There was significant difference between the male and female population of grivet monkey during the dry season ($\chi^2 = 31.111$, df = 1, P < 0.01).

Table 1. Estimated populations of hippopotamus, warthog and grivet monkey in Wonji-Shoa Sugarcane Plantation during wet and dry seasons (all are average totals).

Season	Wet season			Dry season		
Species	Male	Female	Total	Male	Female	Total
Hippopotamus	48	81	129	33	66	99
Warthog	77	103	180	56	84	140
Grivet monkey	352	530	882	245	385	630

The density of male and female hippopotamus during the wet season was 1.6/km^2 and 2.7/km^2 and during the dry season 1.1 km^2 and 2.2 km^2, respectively in the Awash River. The proportion of hippopotamus, warthog and grivet monkey is given in (Fig. 10).

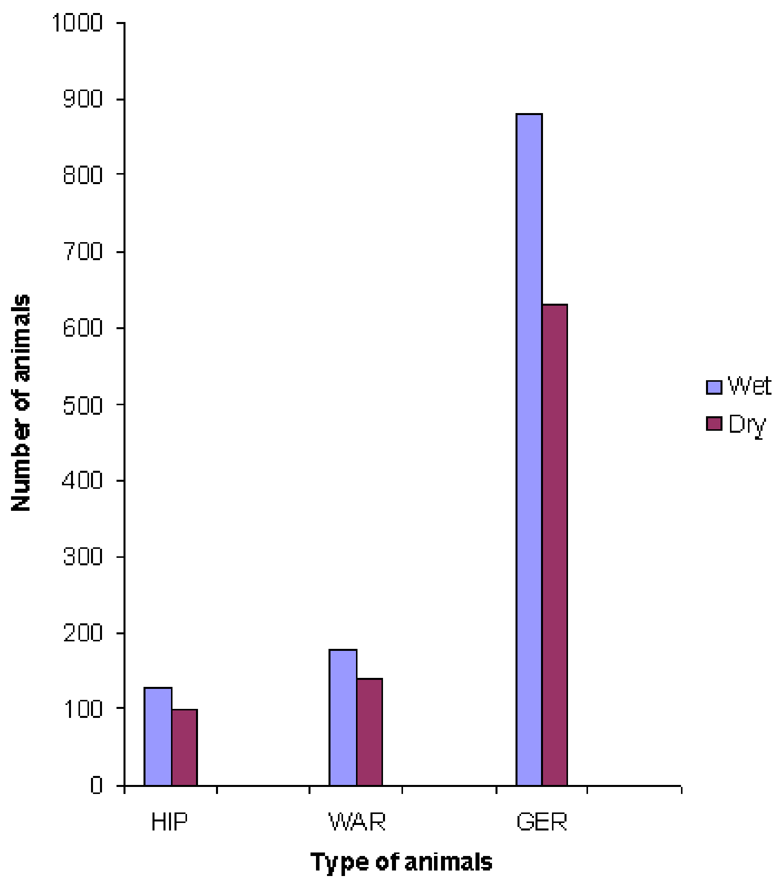

Figure 10. Proportion of hippopotamus, warthog and grivet monkey population during wet and dry seasons. (HIP = Hippopotamus, WAR = Warthog, GER = Grivet monkey).

3.2 Faecal analysis.

Analyses of 16 faecal droppings of hippopotamus showed that the food items such as sugarcane, dicots and unknown materials were used in different proportion during wet and dry seasons, respectively (Table 2). The faecal droppings of hippopotamus are given in Figure 11.

Figure 11. Faecal droppings of hippopotamus at Wonji-Shoa Sugarcane Plantation (Photo: Mesele, 2007).

Table 2. Mean percentage of food items identified from faecal analysis of hippopotamus.

	Wet season			Dry season		
Samples	Sugarcane fragments	Dicot	Unknown	Sugarcane fragments	Dicot	Unknown
1	37.5	62.5	-----	75.0	25.0	-----
2	37.5	62.5	-----	87.5	12.5	-----
3	37.5	62.5	----	87.5	12.5	-----
4	50.0	37.5	12.5	87.5	-----	12.5
5	37.5	37.5	25.0	75.0	25.0	-----
6	37.5	62.5	-----	87.5	12.5	-----
7	37.5	50.0	12.5	87.5	-----	12.5
8	37.5	50.0	12.5	87.5	-----	12.5
9	37.5	62.5	-----	87.5	-----	12.5
10	50.0	37.5	12.5	75.0	25.0	-----
11	50.0	50.0	-----	75.0	25.0	-----
12	37.5	62.5	-----	87.5	-----	12.5
13	37.5	50.0	12.5	75.0	25.0	-----
14	50.0	50.0	-----	75.0	12.5	12.5
15	37.5	62.5	-----	87.5	-----	12.5
16	37.5	62.5	-----	87.5	12.5	-----
Mean Percentage	40.6	53.9	5.5	82.8	11.7	5.5

The sugarcane fragments found in the faecal droppings of hippopotamus significantly differed between wet and dry seasons (χ^2 = 14.23, df = 1, P < 0.01). During wet season, more dicots were consumed than the dry season (χ^2 = 24.242, df = 1, P < 0.01). More sugarcane was also consumed during the dry season than the wet season (T = 16.96, df = 1, P < 0.05). The proportion of sugarcane in the faecal droppings of hippopotamus is shown in Figure 12.

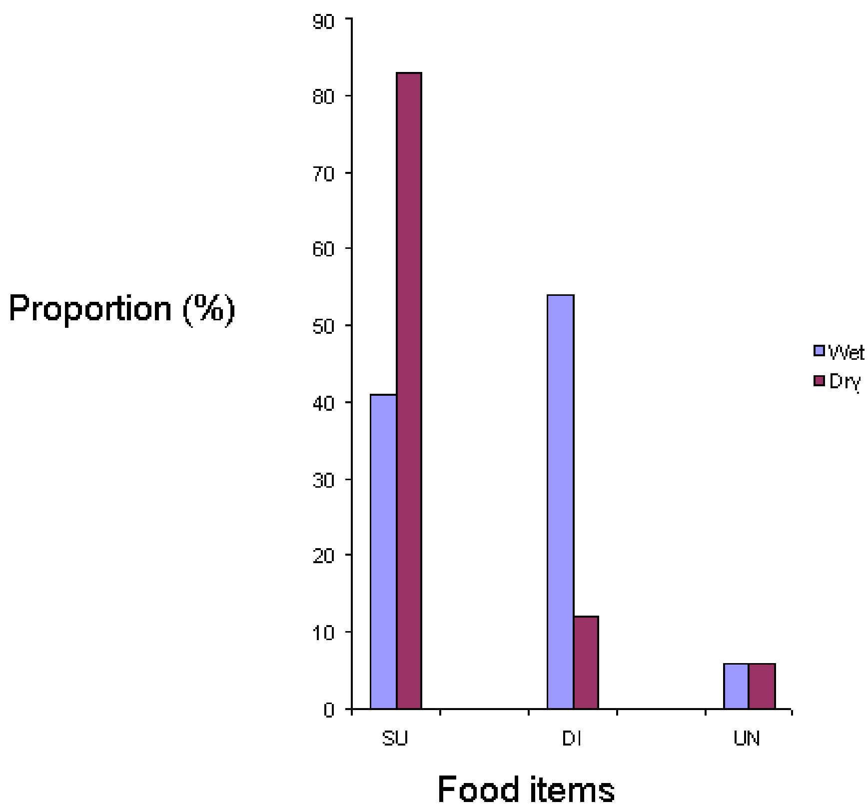

Figure 12. Proportion of food items identified from the analysis of faecal droppings of hippopotamus during wet and dry seasons (SU=Sugarcane, DI= Dicots, UN= Unknown).

Analysis of 16 faecal droppings of warthogs revealed sugarcane, dicots and unknown materials during wet and dry seasons (Table 3). Faecal droppings of warthog are shown in Figure 13.

Figure 13. Faecal droppings of a warthog at Wonji-Shoa Sugarcane Plantation (Photo: Mesele, 2007).

Table 3. Mean percentage of sugarcane fragments from faecal analysis of warthog.

	Wet season			Dry season		
Samples	Sugarcane fragments	Dicot	Unknown	Sugarcane fragments	Dicot	Unknown
1	37.5	62.5	-----	87.5	12.5	-----
2	50.0	37.5	12.5	100.0	-----	-----
3	37.5	50.0	12.5	87.5	-----	12.5
4	50.0	50.0	-----	87.5	-----	12.5
5	37.5	37.5	25.0	100.0	-----	-----
6	37.5	50.0	12.5	100.0	-----	-----
7	37.5	37.5	25.0	87.5	12.5	-----
8	50.0	37.5	12.5	87.5	12.5	-----
9	50.0	50.0	-----	87.5	-----	12.5
10	37.5	62.5	-----	100.0	-----	-----
11	50.0	50.0	-----	100.0	-----	-----
12	37.5	50.0	12.5	87.5	12.5	-----
13	37.5	50.0	12.5	87.5	12.5	-----
14	50.0	50.0	-----	87.5	-----	12.5
15	50.0	50.0	-----	100.0	-----	-----
16	37.5	37.5	25.0	87.5	12.5	-----
Mean Percentage	42.9	47.7	9.4	92.2	4.7	3.1

The sugarcane fragments or plant fibers found in the faecal droppings of warthog significantly differed between wet and dry seasons (χ^2 = 17.785, df = 1, P < 0.01). More sugarcane plant fibers were identified in the faecal droppings of warthog (Fig. 14).

During the wet season, more dicots were consumed than the dry season. It was significantly differed between wet and dry seasons (χ^2 = 34.89, df = 1, P < 0.01).

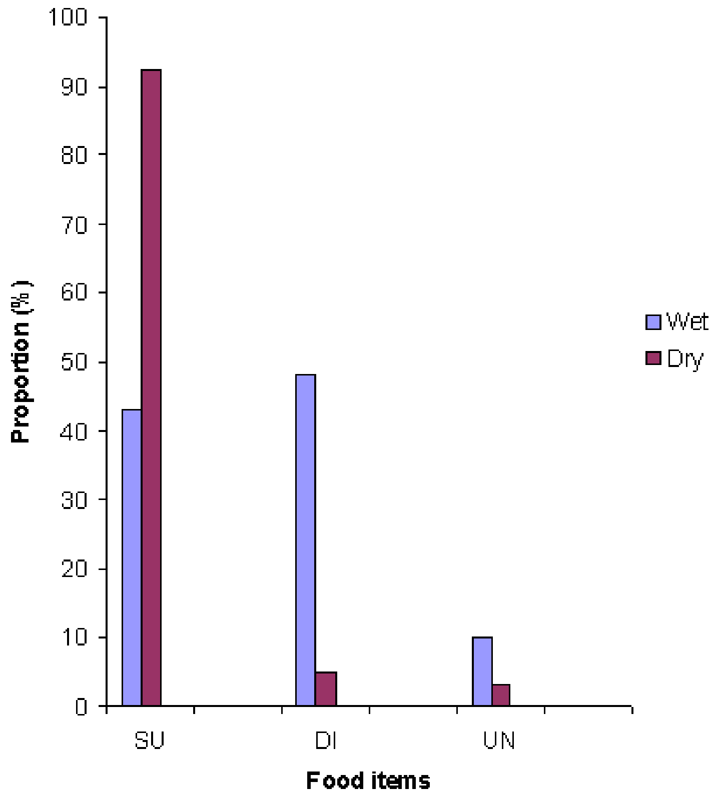

Figure 14. Proportion of food items identified from analysis of faecal droppings of warthogs during wet and dry seasons (SU= Sugarcane, DI= Dicots, UN= Unknown).

3.3 Diet analysis of warthog

The stomach content of the warthog is shown in Figure 15.

Figure 15. Stomach content of warthogs being dried for laboratory analysis (Photo: Mesele, 2006).

Sugarcane fibers identified from the diet of the killed warthog during the dry season constituted 95.3%. In addition, other food items such as dicots (3.1%) and unknown materials (1.6%) together constituted about 4.7% (Fig. 16).

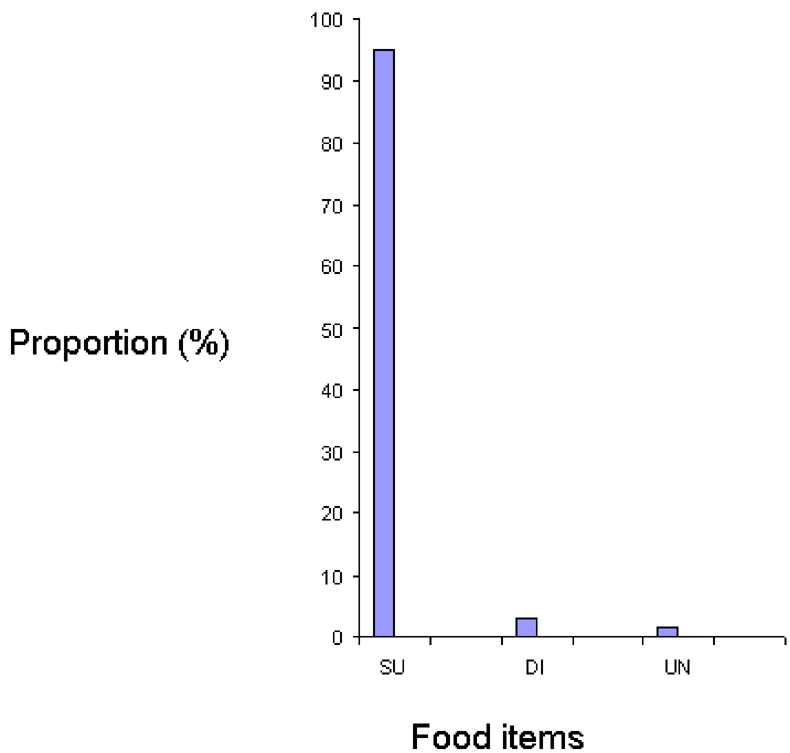

Figure 16. Proportion of food items identified from the diet analysis of killed warthog during the dry season (SU=Sugarcane, DI=Dicots, UN= Unknown).

3.4 Sugarcane damage assessment

Sugarcane damage by hippopotamus, warthog and grivet monkey occurred throughout the year both during the wet and dry seasons in Wonji-Shoa Sugarcane Plantation fields. The extent of damage varied depending upon the season and the type of animal that actually caused the damage (Table 4).

Table 4. Sugarcane damaged/ha during wet and dry seasons by hippopotamus, warthog and grivet monkey (W=wet, D= dry).

	Sugarcane stalk count/ha		Sugarcane damage stalk count/ha		Sugarcane damage percent/ha	
Species	W	D	W	D	W	D
Hippopotamus	96,500	89,545	2,745	3,089	2.8	3.4
Warthog	96,500	89,545	3,988	4,025	4.1	4.4
Grivet monkey	96,500	89,545	3,148	3,590	3.3	4.0

Damage by warthog to sugarcane plantation accounted 3988 and 4025 sugarcane stalk count/ha during wet and dry seasons, respectively (Table 4). The damage between the wet and dry seasons significantly differed between wet and dry seasons ($t = 216.244$, $df = 1$, $P < 0.05$). Warthogs also damaged sugarcane plantation when burrowing in the sugarcane fields.

In some parts of sugarcane fields, the cane plant was totally damaged and replaced by weeds and grasses (Fig. 17). Warthog damage to sugarcane plantation was not only through consuming sugarcane but also through digging burrow to get a place to hide itself from predators, extreme temperature and the cane guards.

Figure 17. Sugarcane field completely changed to weeds and grasses due to warthog damage (Photo: Mesele, 2006).

Warthogs damage sugarcane plantation at the roots and base of the sugarcane stalk which was supposed to give more yields per unit area (Fig. 18).

Figure 18. Sugarcane damaged by warthog around the root and at the base of the stalk at Wonji-Shoa Sugarcane Plantation (Photo: Mesele, 2006).

Damage on sugarcane plantation by grivet monkeys accounted 3148 and 3590 per ha during both seasons. This damage significantly differed between wet and dry seasons ($t = 15.244$, $df = 1$, $P < 0.05$). Grivet monkeys also caused damage by cutting at the middle of the stalk like humans (Fig. 19).

Figure 19. Dried sugarcane damaged by grivet monkey (Photo: Mesele, 2007).

Damage by grivet monkeys also resulted in large amount of decayed matter that clogging the irrigation system of the farm (Fig. 20).

Figure 20. Dried sugarcane damaged by grivet monkey (Photo: Mesele, 2007).

Damage by hippopotamus on the sugarcane plantation constituted 2745 and 3089 sugarcane stalk count/ha during wet and dry seasons, respectively (Table 4). The hippopotamus damage to sugarcane significantly differed between wet and dry seasons ($t = 16.96$, $df = 1$, $P < 0.05$). Hippopotamus repeatedly damage sugarcane plants at the shoots and younger parts of the plant (Fig. 21).

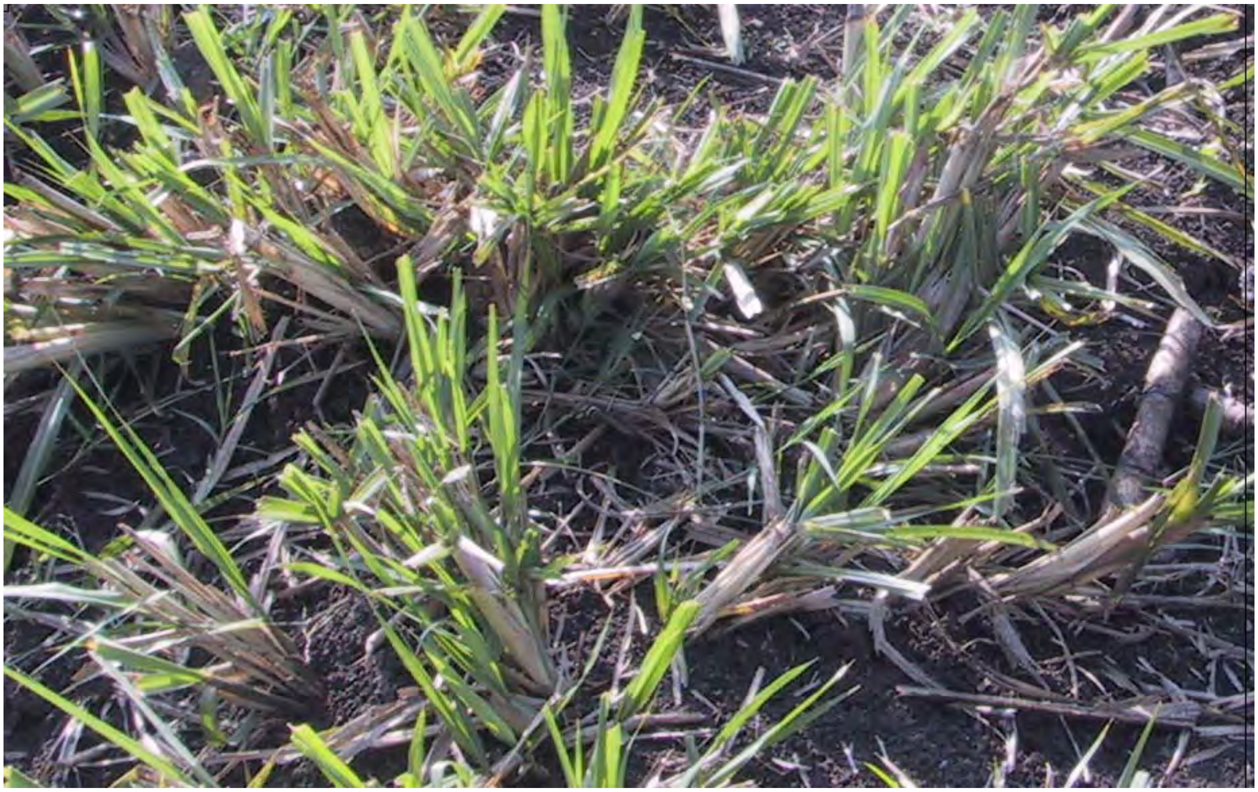

Figure 21. Sugarcane damaged by hippopotamus (Photo: Mesele, 2007).

Sugarcane plantation damage by warthogs was 3988 and 4025 sugarcane stalk/ha which accounted 4.1% and 4.4%. Damage by grivet monkeys was 3148 and 3590 which accounted 3.3% and 4.0% and hippopotamus 2745 and 3089 which constituted 2.8% and 3.4% during wet and dry seasons, respectively (Table. 4). Damage by warthog is higher than hippopotamus and grivet monkey. Damage by grivet monkeys was also higher than hippopotamus both during the wet and dry seasons (Fig. 22). There was significant difference among the damages caused by warthog, hippopotamus and grivet monkey both during the wet season ($t = 8.99$, $df = 2$, $P < 0.05$) and dry season ($t = 13.194$, $df = 2$, $P < 0.05$).

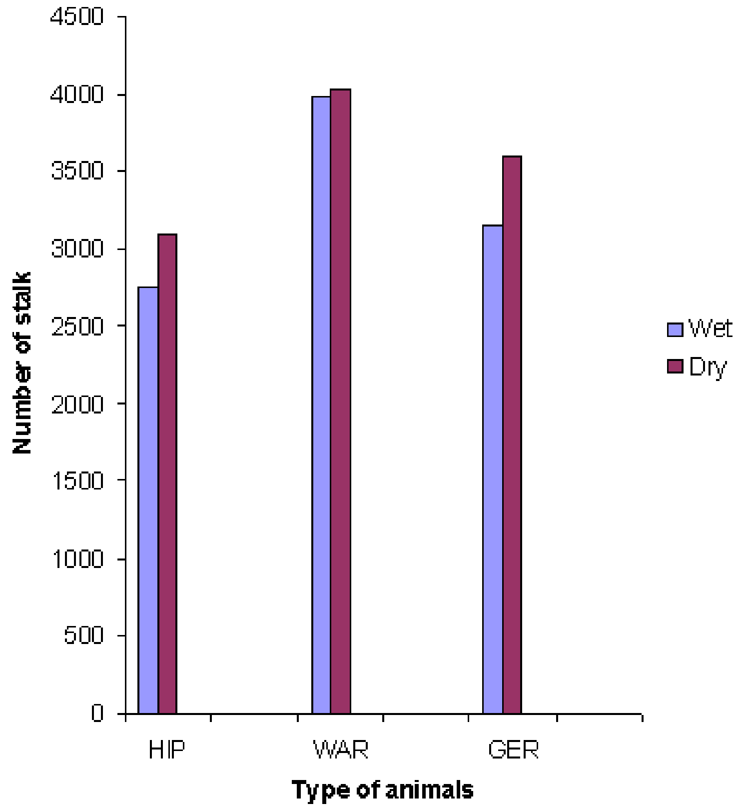

Figure 22. Proportion of sugarcane damage/ha during wet and dry seasons by hippopotamus, warthog and grivet monkey. (HIP=Hippopotamus, WAR= Warthog, GER= Grivet monkey).

A total of 10.2% and 11.8% per ha of sugarcane was damaged by the three large mammals during the wet and dry seasons, respectively in Wonji-Shoa Sugarcane Plantation.

4. Discussion

The present study that was carried out in Wonji-Shoa Sugarcane Plantation showed population estimation of hippopotamus, warthog, and grivet monkey as well as sugarcane damage estimation by these animals. The result of this study showed that there was strong conflict between these animals and the local people as well as the enterprise. The conflict between these animals and the local people increased during the dry season where there are no enough resources for the survival of the species. The competitions for resources cause conflict between wild animals and people. Hill (2000) reported that the wild animal population is increasing and at the same time human populations expand year after year, which resulted in competitions for resources between wild animals and human populations. In the study area, the natural habitats of the animals were modified into sugarcane plantation. As a result, animals in the surrounding area enter the sugarcane plantation and caused damage.

The study showed that the population of hippopotamus in Awash River and around sugarcane plantation varied from season to season. Relatively more hippopotamus population was recorded during the wet season than the dry season. This is because sufficient amount of resources are available during the wet season than during the dry season. Usually rainfall facilitates vegetation growth and provides suitable conditions for the survival of the species. The male and female population of hippopotamus showed variation from season to season. This enables the individuals in the population to find mates for reproduction. This is shows that the population of hippopotamus is relatively in a good status. According to Okello, et al. (2005) hippopotamuses are hunted extensively for their flesh, superior quality of tusk and hide. In the study area, the local people did not hunt hippopotamuses for their meat and tusk. This is because culturally the people in the area do not have a trend to prepare tusk for markets.

However, they hunt hippopotamus for its hide and appreciate the strength and durability of the hide. In addition because of hippopotamus damage to sugarcane plantation and other crops near by Awash River, the cane guards and the farmers near Awash River hunt and shoot hippopotamus against its damage. Although, hippopotamus population is relatively in good status it was decreased during the dry season because of the reasons mentioned above.

Population of warthog was recorded more during the wet season than the dry season. This is because during the dry season resources required for survival of the species are not available in sufficient amount. In addition the conflict between the animals and the local people is not much intense during the wet season. But during the dry season, especially during harvesting period, the local people hunt and shoot warthogs for their meat and against sugarcane damage continuously. When the sugarcane fields were burned for harvesting, the warthogs get out of their burrows and from the fields in order to migrate to other fields which are not harvested at the time. During burning of the sugarcane fields for harvesting, many workers surround the area waiting for warthogs to hunt, when they come out of the field. This makes very difficult for warthogs to escape. As a result, some of them are killed during the harvesting time. This is one of the reasons why warthog population decreases during the dry season. Besides, the natural habitat in the surrounding area was modified for agriculture. As a result, warthogs have no suitable habitat except hiding themselves in the sugarcane plantation. This exposed them to hunting and shooting by the local people. In the present study area, males and females of warthog population showed variation both during the wet and dry seasons. As a result, individuals in the population find mates for reproduction. This enables the population to survive in the area. This shows that the population of warthogs is relatively in a good status, although, it was decreased during the dry season.

P. Vercamen and D.R. Mason (1993) reported that warthogs are easy to hunt and provide large carcass in non – Muslim countries. Most of the local people in Wonji-Shoa area are Christians and they hunt warthogs for their meat and this may affect the male and female population in the area. Besides, the local people believe that warthog's meat is valued as medicine for asthma. This and noted above factors decreased the warthog population during the dry season. This was confirmed by observation during the entire data collection period.

The population of grivet monkey was more abundant during the wet season than the dry season. During the wet season, resources such as fruits, seeds of acacia, leaves and others are available in sufficient amount. The grivet monkey population is high in the study area because they are not hunted by the local people for their meat or for any purpose. In addition, the ability of grivet monkeys to exploit different varieties of food enables them to survive and have large number of population in the area. However, the population decreased during the dry season. This is because during the dry season resources are limited in the area and grivet monkeys move to areas where they can get food and water. The variation in sex ratio provided suitable conditions for individuals to find mates for reproduction. As a result, the grivet monkey population is in a good status in the area. This was confirmed by observation and population estimation both during the wet and dry seasons.

In the study area, sugarcane was mainly damaged by hippopotamus, warthog and grivet monkey. But wild animals such as gazelles, bush-buck and baboons were also observed damaging sugarcane in the area, although, it was not quantified.

Lahm (1996) reported that agricultural crops such as maize, sugarcane and sorghum which grow over two meters conceal larger animals such as hippopotamus, elephants, warthog and primates. Similarly, the current finding showed that the sugarcane plant was observed concealing hippopotamus, warthog, grivet monkey and other large mammals that enter the plantation fields. As a result, the sugarcane was exposed to damage because the animals were not easily observed by the cane guards. Especially this enables warthog to dig burrows in the sugarcane plantation fields and hide itself against the cane guards.

According to Hill (1997), the sugarcane damage tends to increase during the dry season than the wet season. In the study area, sugarcane damage by hippopotamus, warthog and grivet monkey occurred throughout the year because it is an irrigated plantation. But the sugarcane damage increased during the dry season compared to the wet season by the three sugarcane raiding animals in the area (Fig. 22). This was confirmed by direct observation in the field, sugarcane damage assessment and faecal analysis of the cane raiding animals during the wet and dry seasons (Tables 2 and 3) and diet analysis during the dry season (Fig. 16).

Hippopotamus is fond of sugarcane and corn and enter plantations where it does more damage by trampling the plants than it does by feeding (World Almanac, 2007). Similarly, in the study area, hippopotamus was repeatedly observed in the sugarcane plantation fields. Hippopotamus usually damages the sugarcane by grazing on the young shoots of the cane (Fig. 21). The damage was not only by feeding on the shoots of the cane, but also by trampling and destroying certain areas of the field. This was confirmed by direct observation in the field, presence of hoof marks and faecal droppings in the fields.

The current finding showed that about 2.8% and 3.4% of sugarcane plantation per ha was damaged by hippopotamus during the wet and dry seasons, respectively (Table 4). The sugarcane damage increased during the dry season (Fig. 22). This is because during the dry season there was shortage of food to get outside the plantation fields. Besides, fond of sugarcane plantation the hippopotamus, it has no other foraging sites near the vicinity. Sugarcane damage by hippopotamus in the study area was confirmed by direct observations in the field early in the morning and late in the afternoon during the entire data collection period, faecal analysis during the wet and dry seasons and damage assessment during the wet and dry seasons.

More sugarcane fragments (40.6% and 82.8%) were obtained from faecal analysis of hippopotamus during the wet and dry seasons, respectively. The sugarcane fragments found in the faecal droppings of hippopotamus was more during the dry seasons than the wet season. This showed that hippopotamus feed more in the sugarcane plantation than other food items during the dry season because there was scarcity of other food items other than sugarcane plantation during the dry season in the area. This shows that sugarcane damage is high during the dry season where animals do not get other resources. During the wet season more dicots were consumed instead of sugarcane. This showed that hippopotamus is one of the sugarcane raiding animals in the study area.

Warthogs severely damage crops when their habitats overlap with an agricultural area (Kingdom, 1997; Kleiman, et al., 2004; Vercamen and Mason, 1993). In the study area, warthogs were observed causing damage to sugarcane. This is because the original habitat of the warthogs has been modified for sugarcane plantation in the area.

The present finding showed that about 4.1% and 4.4% of sugarcane stalk per ha was damaged by warthogs during the wet and dry seasons, respectively. The sugarcane damage tends to increase during the dry season (Hill, 1997). Similarly, in the present study area, the sugarcane damage by warthogs increased during the dry season as well as during the harvesting period where there is limited food items and water in the surrounding area. Similarly, Vercamen and Mason (1993) reported that warthogs cause damage to rice, peanuts, maize and sugarcane both during the wet and dry seasons but the damage escalated the during dry season.

In the study area damage by warthogs to sugarcane plantation was confirmed by direct morning and late afternoon observation in the field, faecal analysis and diet analysis. Warthogs are active early in the morning and in the late afternoon. Similarly, Ermias Deribe (2001) reported that the daily activity pattern of warthogs is characterized by morning and late afternoon with a period of rest in the middle of the day. Although, warthogs are diurnal they are not active the whole day because they hide themselves against predators, extreme temperature and hunters in self-excavated burrows in the middle of the day when people are active. In the study area, warthogs excavate burrows in the sugarcane plantation fields and hide themselves against predators, extreme temperature and the cane guards. When warthogs dig burrows in the plantation fields, they caused greater damage to sugarcane (Fig. 5).

The sugarcane fragment found in the faecal droppings of warthog was more during the dry season than the wet season. This is because the warthogs feed more in the sugarcane plantation during the dry season when other resources are limiting and caused more damage to sugarcane. The diet analysis of warthog also revealed more (95.3%) sugarcane fragments. This shows that warthogs regularly feed on the sugarcane during the dry season. Both the faecal and diet analyses confirmed that warthogs cause more damage to sugarcane during the dry season than the wet season. However, sugarcane damage occur both during the wet and dry seasons. Warthogs damaged sugarcane at the roots and base of the sugarcane stalk which was expected to give more yield per unit area (Fig. 18). Kingdon, (1997); kleiman, et al. (2004) also reported that warthogs use their snouts and tusks to excavate rhizomes and bulbs. This shows that warthogs dig the roots of the sugarcane for consumption.

Naughton-Treves (1998) reported that in Uganda primates are dominant pests and responsible for over 70% of the damage events and 50% of the area damaged due to their intelligence, adaptability, wide dietary range, complex social organization and manipulative abilities. In the present study, 3.3% and 4.0% sugarcane damage was observed by grivet monkeys in the study area. This sugarcane damage is due to the social organization and intelligence of the animal to recognize the absence of cane guards and then immediately rushes into the plantation fields forming different groups in different directions. This kind of social organization of grivet makes the damage incidence high because it is difficult to chase them away since they come to the plantation fields in different directions in large numbers.

The sugarcane damage by grivet monkeys was recorded more during the dry season than the wet season. This is because, during the dry season, there is limited food and water in the surrounding area, other than in the plantation fields. Grivet monkeys do not get alternative food items, such as, grasses, leaves, seeds of fruits, seeds of acacia and others during the dry season. As a result, their only foraging site is the sugarcane plantation. This increased the sugarcane damage by the grivet monkeys more during the dry season than the wet season. Similarly, (Hill, 1997) reported that sugarcane damage tends to increase during the dry season than the wet season.

Hill (2000) reported that farms located within 300 meter of a forested boundary probably are exposed more to crop-raiding by grivet monkeys. In the study area, the plantation fields are very near to Awash River where there are plenty of trees which support grivet monkeys by providing shelter to escape from the cane guards.

According to Eudey (1994), for Hindus, monkeys are sacred animals and in parts of northern India, Indonesia and other areas, they are worshiped, protected and provisioned by the villagers. They can very easily raid crops in their surroundings. In the study area, grivet monkeys are not considered sacred but the people in the area do not have a trend to hunt grivet monkeys except chasing them away from their crops. This is because the people in Wonji- Shoa area neither eat grivet monkey meat nor use their hide for different purposes. This has increased the sugarcane damage in the area.

The presence of large scattered trees has helped grivet monkeys as an escaping site from guards. Grivet monkeys were observed cutting the sugarcane stalk around the middle and chew it like humans (Fig. 19). They also damage the stalk while they jump from one cane to another. The broken leaves and stems of the cane can affect the irrigation system by clogging small ditches which provide water to the entire field (Fig. 20).

Hill (1998) reported that crop losses by wild animals can be enormous both in the direct economic terms and through indirect costs on time and energy devoted to protection and replanting after damage. In the present study area, the Wonji-Shoa Sugarcane Plantation Department was observed spending considerable amount of money to employ cane guards to prevent the sugarcane damage both during the day and night time. The Department also spends money, time and energy to replant the sugarcane plant that is completely damaged and changed to weeds and grasses (Fig. 17). This was confirmed by direct observation in the sugarcane plantation fields where the cane guards were on duty and through information obtained from Sugarcane Plantation Department office documents, as well as from monthly reported documents of section heads. The documents emphasize damage caused by different animals and request to employ additional cane guards to minimize the problem. A total of 10.2% and 11.8% per ha of sugarcane was damaged by the three large mammals during the wet and dry seasons. Since sugarcane is the raw material for the Sugar Factory, loss of this raw material resulted in reduced production of sugar. Besides, reduced output, expenses incurred to plant and guard the plantation reduces gross product of the sugar factory. This in turn, affects the economy of the country.

5. Conclusion and recommendations

Human wildlife conflict is an increasing concern in all parts of the world and recently has become the focus of conservation efforts. Human population growth and activities such as deforestation and urbanization lead to an increased encroachment of wildlife habitats. As the natural habitat of the wild animals is modified for agriculture, wild animals will not have enough space, food and other resources to survive. As a result, the requirements of wildlife overlap with the people in the area. This leads to severe competition for resources between wild animals and people.

Although crop damage by wild animals is a widespread problem, it is more severe in developing countries especially in Africa due to habitat encroachment and population pressure. The Wonji-Shoa Sugarcane Plantation was established by modifying the natural habitats of wild animals in the area. Due to encroachment of their habitats, animals in the area moved to the plantation fields to get space food and other resources. This resulted in sugarcane damage by the animals.

The data collected during the present study provide important information on population and pest status of the hippopotamus, warthog and grivet monkey in Wonji-Shoa Sugarcane Plantation both during the wet and dry seasons. The occurrence of sugarcane fragments in the faecal droppings as well as in the stomach content confirms the pest status of these animals. Among these animals, warthog caused greater damage to sugarcane than hippopotamus and grivet monkeys. Most of the burrows of warthogs are occur in the plantation fields creating suitable conditions to feed on sugarcane plantation and survive.

Ultimately, based on the results of the present study, the following recommendations are suggested:

- Plantation fields along the boarder line of Awash River should be fenced using strong materials to prevent from hippopotamus damage.
- Hippopotamus can not jump, thus, digging a ditch which is about one meter deep and two meters wide along the boarder line of Awash River may prevent sugarcane damage.
- There should be a physically delineated area between the sugarcane plantation fields and Awash River as well as surrounding natural habitats of the animals.
- Planting unpalatable plants such as sisal or hot pepper spray on the boarder line of the sugarcane plantation will help minimize the animals that visit the plantation fields.
- To strengthen the guarding activities by employing more people especially early in the morning and late in the afternoon will help prevent from warthog damage.
- Enough cane guards should be assigned where there are trees in and around the plantation area to prevent sugarcane damage by grivet monkeys.
- The Plantation Department must cooperatively work with wildlife managers to minimize the sugarcane damage.

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