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Full Length Research.

DAMAGE CAUSED BY LARGE MAMMALS ON SUGARCANE PLANTATION, ETHIOPIA.

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A study to determine the extent of damage by large mammals on sugarcane plantation was carried out in Wonji-Shoa Sugarcane Plantation, central Ethiopia, from August 2006 to March 2007. Three sample sites were randomly selected in the sugarcane plantation to collect data on sugarcane and faecal droppings of the animals. Strip line transect method was used to estimate hippopotamus population while total count method was utilized for warthog and grivet monkeys. Data were analysed using descriptive statistic, chi-square and t-test. There was a seasonal variation in the population number of the three species in the area. The estimated hippopotamus population was 129 and 99 during the wet and dry seasons. The variation was significantly different ($\chi^2 = 3.947$, df =1, P < 0.05). The estimated warthog populations 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 882 and 630 during the wet and dry seasons ($\chi^2 = 42.00$, df = 1, P < 0.01). More number of individuals was recorded during the wet season than the dry season. Grivet monkey population was most abundant and hippopotamus number was the least. 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 to the sugarcane plantation was more for warthog than hippopotamus and grivet monkey. Damage caused by warthog was 3988 and 4025 stalk per ha and that of grivet monkey was 3148 and 3590 stalk per ha during wet and dry seasons, respectively.

Keywords*:* Sugarcane plantation, Pest mammals, Ethiopia

INTRODUCTION

Ethiopia is one of the most physically and biologically diverse countries of the world (Leykun, 2000). It comprises highland massive surrounded by arid lowlands. It contains various wildlife and wildlife habitats ranging from 110 m below sea level at Afar depression to over 4,500 m at Ras Dejen (Shibru, 1995). Most highlands harbour many endemic plants and animals, but possess 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). For millenia, the natural habitats of the country have been altered because of human settlement. Most of the highlands and some of the lowlands have been modified into agricultural and pastoral lands. This has further led to encroachment into wildlife habitats. The constriction of wildlife habitats resulted in severe competition for natural resources between wild animals and the local communities. This in turn resulted in human - wildlife 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 varied depending on the species of the pest mammal in different parts of the country. There are wide varieties of pest mammal species such as hippopotamus, warthog, baboons, monkeys, gazelles, bushbucks 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 *et al.* (2008) on rodent damage in Wonji-Shoa Sugarcane Plantation.

These large mammals largely use sugarcane as their source of food resulting in the destruction, reduction of the sugarcane yield per unit area, increased cost of production and human labour (Wonji-Shoa Sugar Factory Working Manual, 2004). The current study is aimed at estimating the population and collecting data on the extent of sugarcane damage caused by hippopotamus, warthog and grivet monkeys.

THE STUDY AREA

The present study was carried out at Wonji-Shoa Sugarcane Plantation; located at about 110 km southeast of Addis Ababa. It is situated between 8° 21' to 8° 29'N and 39°12' to 39° 18'E at an elevation of 1540 m (Fig.1). Furrow irrigation 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. An efficient system was developed to grow sugarcane through the years that comprised irrigation canals with a total length of 300 km, drainage canals of 200 km, and numerous small artificial lakes. All these water canals depend on Awash River (Wonji-Shoa Sugar Factory Manual, 2004). The climate of Wonji-Shoa area is tropical with wet and dry seasons. Short rains, occur from March to May merging into the main rain season from mid-June to mid-September. The highest rainfall was registered during July and August and minimum during December and January. The annual relative humidity ranges from 34.5 and 63%. The mean monthly minimum temperature is between 6.9°C and 14.7°C (November) and that of maximum is between 23.1°C and 30°C (May).

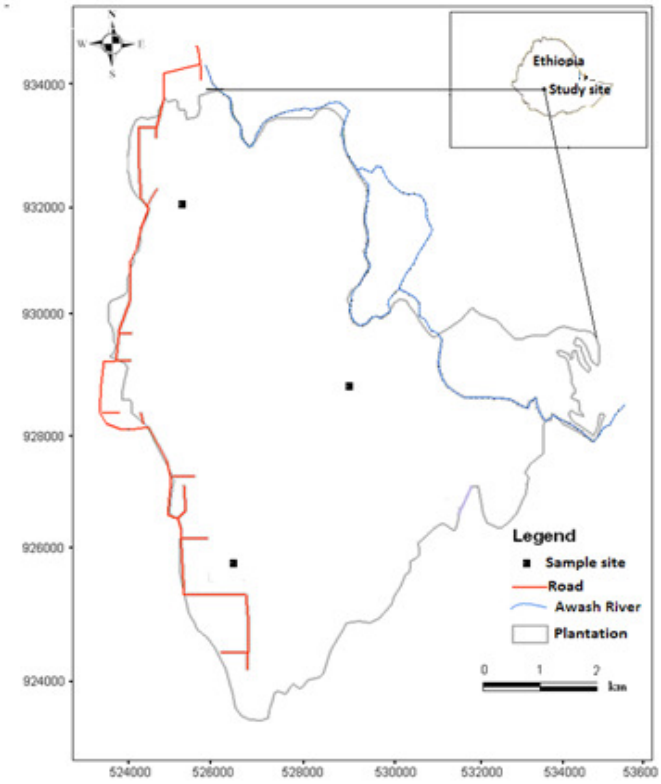

Figure- 1. Map of the study area

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 to light clay soils. The plantation has flat topography and sugarcane is cultivated as perennial monocrop.

MATERIALS AND METHODS

Population estimation

Data on population estimation of hippopotamus, warthog and grivet monkey in Wonji-Shoa Sugarcane Plantation were collected during both the wet and dry seasons. This was performed twice during wet season (August to October, 2006) and dry season (December 2006 to March 2007). Total count method was used to estimate warthog population and the plantation area was divided into three sample sites. Nine individuals were employed to count the warthog population. Three individuals were assigned in one counting site. Density was estimated by dividing the number of animals counted by the area of the study area.

To estimate the grivet monkey population, total count method was used to avoid biases that may be caused due to the rapid movement of grivet monkeys from one place to the other. Counting in the three sites was carried out simultaneously. To estimate the hippopotamus population, strip line transect method was used. Hippopotami outside the strip transect were not counted (William, 1996). Six strip transect samples were randomly laid across the Awash River course. Data were collected by six individuals to record hippopotami found within one km length and 900 m 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. The total population of hippopotamus was calculated by multiplying the density of population with the total area and direct count in the river using binoculars

$D = \frac{N}{L \times 2 \times w}$ D = Density, N = number of hippos counted, L = Length of strip sample and w = width of the strip sample .

Grivet monkeys usually chew sugarcane like humans cutting at the centre of the matured sugarcane plant, especially at the nodes. To estimate the damaged plants, the plants consumed or damaged at the middle were counted in the sampled fields. Ecological information was obtained from the analysis of faecal deposits following Putman (1984). Faecal samples of hippopotamus and warthog were collected from the 16 fields of sugarcane plantation which were sampled in the study area. Faecal droppings of these animals were collected at an interval of 250 m. A total of 64 faecal samples (warthogs) and 80 faecal samples (hippopotami) were collected from the sample area. Faecal droppings were dried and then washed with distilled water. Then, the samples were microscopically observed for the presence or absence of sugarcane fragments. Stomach content of a killed warthog was taken, dried, washed with distilled water and then observed microscopically in the laboratory for the presence of sugarcane fragments.

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 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 of 5 km apart from each other. To estimate the hippopotamus population, six strip line transect samples were laid across the Awash River course. To estimate the grivet monkey and warthog population, the total area was divided into three counting sites. All the data collected were analyzed using SPSS version 13 computer software programs. To assess the significance of sugarcane damage by animals in the study area and estimate the extent of damage, a descriptive statistics, and t-test was used.

RESULTS

Large mammals that caused extensive damage to sugarcane plantation were mainly hippopotamus (*Hippopotamus amphibus*), warthog (*Phacochoerus africanus*) and grivet monkey *(Cercopithecus aethiops*). The estimated population of hippopotamus during the wet and dry seasons was 129 and 99, respectively (Table 1).

Table- 1. Estimated individuals of hippopotamus, warthog and grivet monkey in Wonji-Shoa Sugarcane Plantation during wet and dry seasons.

	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 number of hippopotamus 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. There was a significant difference between male and female number during the wet season ($\chi^2 = 8.442$, df = 1, P < 0.05). Males and females comprised 33 and 66 during the dry season, respectively (Table 1). There was a significant difference between the population size between males and females during the dry season ($\chi^2 = 11.0$, df = 1, P < 0.05).

The estimated warthog population was 180 and 140 during the wet and dry seasons, respectively (Table 1). The number of individuals significantly differed between the wet and dry seasons ($\chi^2 = 5.00$, df = 1, P < 0.05). There were 77 males and 103 females during the wet season. There was a significant difference between male and female population during the wet season ($\chi^2 = 3.756$, df =1, P < 0.05). Males and females also comprised 56 and 84 during the dry season, respectively. There was a significant difference between 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 and 630, respectively, which was significantly different ($\chi^2 = 42.00$, df = 1, P < 0.01). Males and females comprised 352 and 530 during the wet season, respectively. There was a significant difference between male and female population during the wet season ($\chi^2 = 36.369$, df = 1, P < 0.01). Males and females comprised 245 and 385 during the dry season, respectively. There was a significant difference between male and female individuals of grivet monkey during the dry season ($\chi^2 = 31.111$, df = 1, P < 0.01).

Analyses of 16 faecal droppings of hippopotamus showed that sugarcane, dicots and unknown materials were used in different proportion during the wet and dry seasons. The sugarcane fragments found in the faecal droppings of hippopotamus significantly differed between wet and dry seasons (40.65% and 82.8%) ($\chi^2 = 14.23$, df =1, p < 0.01). During the wet season, more dicots were consumed than the dry season, 53% and 11.7%, respectively ($\chi^2 = 24.242$, df = 1, P < 0.01). The mean sugarcane fragments found was 40.6%, dicot 53.9%, unknown 5.5% during wet season and 82.8%, 11.7%, 5.5% during the dry season respectively in hippopotamus faecal droppings. The sugarcane fragments found was 42.9%, dicot 47.7%, unknown 9.4% during the wet season and 92.2%, 4.7%, 3.1% during the dry season, respectively in the warthog droppings (Table 2).

Table- 2. Mean percentage of food items identified from faecal droppings of hippopotamus and warthog

Species	Wet season			Dry season		
	Sugarcane fragments	Dicot	Unknown	Sugarcane fragments	Dicot	Unknown
Hippopotamus	40.6	53.9	5.5	82.8	11.7	5.5
Warthog	42.9	47.7	9.4	92.2	4.7	3.1

Plant fragments found in the faecal droppings of warthog significantly differed between wet and dry seasons 42.9% and 92.2%, respectively. More sugarcane fragments were identified in the faecal droppings of warthog. During the wet season, more dicots were consumed than the dry season 47.7% and 4.7%, respectively. It significantly differed between wet and dry seasons ($\chi^2 = 34.89$, df = 1, P < 0.01). Sugarcane fragments identified from the diet of 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%.

Sugarcane damage by hippopotamus, warthog and grivet monkey occurred throughout the year both during the wet and dry seasons. However, the extent of damage varied depending upon the season and the type of animals (Table 3).

Table-3. Sugarcane damage/ha during wet and dry seasons by hippopotamus, warthog and grivet monkey

Species	Sugarcane stalk count/ha		Sugarcane damage stalk count/ha		Sugarcane damage (%/ha)	
	Wet	Dry	Wet	Dry	Wet	Dry
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 caused by warthog to sugarcane plantation accounted 3988 and 4925/h (sugarcane stalk count/ha during wet and dry seasons, respectively). In some parts of sugarcane fields, the cane plant was totally damaged and replaced by weeds and grasses. Warthog damage to sugarcane plantation was not only through consuming sugarcane but also through digging burrow to get a place to hide from predators, extreme temperature and the sugarcane plantation guards. Warthogs damage sugarcane plantation at the roots and base of the sugarcane stalk which was supposed to give more yields per unit area.

Damage on sugarcane plantation by grivet monkeys accounted 3148 and 3590/ha during both seasons ($t = 15.244$, $df = 1$, $P < 0.05$). Grivet monkeys also caused damage by cutting at the middle of the stalk like humans. Damage by grivet monkeys also resulted in large amount of decayed matter that clogged the irrigation canal of the farm.

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

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%. Damage by hippopotamus was 2745 and 3089 which constituted 2.8% and 3.4% during wet and dry seasons, respectively. Damage by warthog is higher than hippopotamus and grivet monkeys. There were significant differences among the damage caused by warthog, hippopotamus and grivet monkey both during the wet season ($t = 8.99$, $df = 2$, $P < 0.05$) and dry seasons ($t = 13.194$, $df = 2$, $P < 0.05$). 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.

DISCUSSION

The present study showed that there was strong conflict among the large mammals, local residents and the enterprise. The conflict was more severe during the dry season because resources were limiting. Hill (2000) reported that competition results as a result of increase both in wildlife and human population. 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 cause damage.

The study showed that the population of hippopotamus in the 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 was because more resources are available during the wet season than the dry season compared to the other areas. 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 enabled individuals to find mates for breeding. In many localities hippopotami are hunted extensively for their meat, superior quality of tusk and hide (Okello *et al*., 2005). In the study area, the local people do not hunt hippopotamus for their meat and tusk. This is because culturally the people in the area do not have a know how to prepare the tusk for markets. However, they hunt hippopotamus for the hide and appreciate the strength and durability of the hide. In addition, because of hippopotamus damage to sugarcane

plantation and other crops nearby Awash River, sugarcane guards and farmers hunt and shoot hippopotamus to minimize the damage. Population of warthog was recorded more during the wet season than at the dry season. This is because during the dry season resources are limiting and are not available in sufficient amount. In addition, the conflict between these species and the local people is not 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. During the burning process of sugarcane fields for harvesting, warthogs move out of their burrows and fields in order to migrate to other fields which are not harvested at the time. During this process, many workers surround the area waiting for warthogs to hunt when they come out of the field. This makes warthogs vulnerable thereby decreasing the population number during the dry season. Besides, the natural habitat in the surrounding area was modified for agriculture. As a result, warthogs lack suitable habitat except hiding themselves in the sugarcane plantation. Sex ratios showed variation, both during the wet and dry seasons. When population size increases, individuals in the population find ample mates for breeding. Vercamen and Mason (1993) reported that warthogs are easy to hunt and provide food 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 population in the area. Besides, the local people believe that the meat of warthog is valued as medicine for asthma.

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* and leaves of other plants are available in sufficient amount. At the same time, they are not hunted by the local people for their meat or any other purpose. In addition, the ability of grivet monkeys to exploit varieties of food enables them to survive and produce large number of individuals in the area. However, the population decreases during the dry season because resources are limiting in the area and as a result, they migrate to areas where they can get food and water. The variation in sex ratio provided suitable conditions for individuals to find mates for breeding. As a result, the grivet monkey number was high.

Lahm (1996) reported that crops such as maize, sugarcane and sorghum which grow over two metres conceal larger animals such as hippopotamus, elephants, warthog and primates. Similarly, the sugarcane plantation was observed concealing hippopotamus, warthog and other large mammals that enter the plantation fields. According to Hill (1997), sugarcane damage tends to increase more 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. However, sugarcane damage increased during the dry season compared to the wet season by these raiding animals because of limiting resources in the surrounding. This was confirmed by direct observation in the field, sugarcane damage assessment and faecal analysis during the wet and dry seasons and diet analysis during the dry season.

More sugarcane fragments (40.6% and 82.8%) were obtained from faecal analysis of hippopotamus during the wet and dry seasons, respectively. Sugarcane fragments found in the faecal droppings of hippopotamus were more during the dry season 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. Warthogs severely damage crops when their habitats overlap with an agricultural area (Kingdon, 1997, Vercamen and Mason, 1993). In the study area, warthogs were observed causing damage to sugarcane as their original habitat was modified for sugarcane plantation in the area.

The present finding showed that 4.1% and 4.4% of sugarcane stalk per ha was damaged by warthogs during the wet and dry seasons, respectively. Sugarcane damage tends to increase slightly during the dry season (Hill, 1997). Similarly, in the present study area, sugarcane damage by warthogs increased during the dry season where there is limited food items and water in the surrounding area. The sugarcane fragment found in the faecal droppings of warthog was more abundant during the dry season than the wet season. This is because warthogs feed more in the sugarcane plantation during the dry season when other resources are limiting. Warthogs damage sugarcane at the roots and base of the sugarcane stalk which was expected to give more yield per unit area. Kingdon (1997) also reported that warthogs use their snouts and tusks to excavate rhizomes and bulbs.

Naughton-Treves (1998) reported that in Uganda primates are the dominant pests, responsible for over 70% of the damage 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. Sugarcane damage by grivet monkeys recorded was more during the dry season than the wet season as there is limited food and water in the surrounding area, other than in the plantation fields. Similarly, Hill (1997) reported that sugarcane damage tends to increase during the dry season than the wet season. Hill (2000) also reported that farms located within 300 m of a forested boundary are exposed more to crop-raiding by grivet monkeys than others. In the study area, the plantation fields are very near to Awash River where there are riverine trees which support grivet monkeys by providing shelter to escape from the cane guards.

Hill (1998) reported that crop losses by wild animals can be enormous both in direct economic terms and through indirect costs on time and energy devoted to protection and replanting after damage. In the present study area, Wonji-Shoa Sugarcane Plantation Department spends considerable amount of money to employ cane guards to prevent the sugarcane damage both during day and night. The department also spends money, time and energy to replant the fields that are completely damaged. 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. As sugarcane is the raw material for the sugar factory, loss of this raw material results in reduced production of sugar. Besides, reduced output, expenses incurred to plant and guard the plantation, can result in reduced gross product.

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