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POPULATION STATUS AND ECOLOGY OF COMMON HIPPOPOTAMUS (*Hippopotamus amphibius*, LINNAEUS, 1758) IN BOYE WETLAND, JIMMA, ETHIOPIA, WITH SPECIAL REFERENCE TO THE HUMAN AND ANIMAL CONFLICT

BY: SEFI MEKONEN

ADVISOR: K. K. SUBHASH BABU (PhD)

CO-ADVISOR: TSEGAYE GADISA (PhD)

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LIST OF ACRONYMS

CITES: Convention on International Trade in Endangered Species

EPA: Environmental Protection Authority

FAO: Food and Agriculture Organization

GPS: Global Position System

IBC: Institute of Biodiversity Conservation

IUCN: International Union for Conservation of Nature and Natural Resources

UNEP: United Nations Environment Programme

WCMC: World Conservation Monitoring Centre

WWC: World Water Council

ABSTRACT

A study on the population status, ecology and human conflicts of hippopotamus (Hippopotamus amphibius) was conducted in Boye wetland between February and August, 2013. Total ground count, field observations, interviews and questionnaire techniques were used to collect data. The behavioural activity and event patterns were studied with 30 minutes interval following a male and female focal individual. The average of 14.75 ± 1.89 of hippopotamus was recorded in the study area. Among them, 32.20% was males, 44.07% females and 23.73% young. However, the population composition had no statistical differences (F = 0.683, df= 2, P = 0.518). The male to female sex ratio was 1.00:1.37. But, young to adult age individual ratio was 1.00:3.21. During the rainy season, hippopotamus migrated into Gibe River. The population size of hippopotamus counted at Boye wetland and Gibe River had no significant difference (P>0.05). Resting comprise the majority of their activity with 42.50%, followed by moving 34.16%, feeding 19.63% and mating 3.71% of day time. Barking and yawning events took 51.18% and 48.82% of their time, respectively. Males spent more time in resting than females, while females were active in all behavioural activity and event patterns except mating activity. Feeding and moving peak activities were observed early in the morning and late afternoon hours with resting peak during the mid-day. Barking and yawning events were mostly increased in the afternoon. Hippopotamus consumed a total of 26 species of plants. Of these, Eriochloa fatmensis (11.68%), Typha latifolia (9.91%), Echinocloa pyramidalis (9.59%) and Cynodon dactylon (8.45%) were the top four species of plants contributing for 39.63% of their overall diet. Hippopotamus's footprint had an average of 81.00cm circumference and 84.94cm distance of slips. Footprint circumferences and distance were positively correlated (r=0.795). Among the respondents, 47.3% had negative attitude towards hippopotamus, while 37.3% and 15.5% had positive and neutral attitudes, respectively. Conflicts with human and other anthropogenic factors influenced hippopotamus distribution in the study area. Therefore, it is recommended that prohibit the expansion of human settlements should not be encouraged in the hippopotamus habitat. Awareness creation around this local people and community participation in the conservation programme also recommended.

Keywords: Attitude, Boye wetland, Feeding ecology, Hippopotamus, Human-hippopotamus conflict, population status.

1. INTRODUCTION

1.1. Background of the study

Assessments of wildlife populations, distribution and ecology are important means to evaluate sources and impacts of human actions in natural environment and to understand the natural rates of wildlife changes (Balmford *et al*., 2003). Wildlife populations in Ethiopia have diminished over the past century through loss of habitat, hunting and land clearance for farming as well as due to land degradation due to overgrazing (IBC, 2009). The constriction of wildlife habitats resulted in severe competitions for natural resources between wild animals and local communities. This in turn, resulted in wildlife human conflicts (Yalden and Largen, 1992). Wetland biodiversity is also getting lost as wetlands are being converted to farmlands in Ethiopia (IBC, 2009).

Effective management of wildlife depends largely upon understanding and predicting their habitat requirements and accurately assessing habitat quality (Martin and Bateson, 2007). Ecological conditions in which animals live keep on changing. Megafauna are extremely sensitive to disturbances and human impacts (Owen-Smith, 1989). As such, several megafauna may be vulnerable or prone to extinction. Monitoring on large mammal populations is a prerequisite for better wildlife management because they can indicate the status of the ecosystem health (Wanyama *et al*., 2009). In the light of this, the present study was mainly focused on the population status, ecology and the extent of human interactions in the habitat and impacts on Common hippopotamus *(Hippopotamus amphibius)* in Boye wetland in Jimma Zone of Oromiya National Regional State, Southwest Ethiopia

Common hippopotamus is the third largest herbivorous African mammal next to African elephant (*Loxodonta africana)* and Rehinosorus (*Diceros bicornis*). *Hippopotamus amphibius* is an unmistakable species, with a plump and thick-body, huge and round-head; great, bulk and short limbs, very large tusk-like canines, broad snout, short-tail and short stocky legs. Their eyes, ears, and nostrils are placed on the high roof of the skull (Grubb, 1993). Common hippopotamus referred to as hippo or hippopotamus (Eltringham, 1999), but in this study it will be subsequently referred to as hippopotamus.

Hippopotamus belongs to the Class Mammalia, Order Artiodactyl, suborder Suiformes, Family Hippopotamidae, Genus *Hippopotamus* and Species *amphibius* (Grub, 1993; Jones, 2008). Males hippopotamus outweigh females (Jones, 2008). The thin epidermis of the skin makes hippopotamus vulnerable to desiccation. For additional protection from the sun, their skin secretes a natural sunscreen substance known as "blood sweat". Nevertheless, their skin will crack if exposed to air for too long due to lack of sweat glands (Eltringham, 1993).

Hippopotamus is a selective grazer consuming 35 to 50 kg of grass or about 2.5% of their body weight daily (Chansa *et al.*, 2011; Théophile *et al.*, 2012). It differs from other mega-herbivores in having a dual requirement of daily living space in water and open grazing range (Eltringham, 1993). Due to their large body size and related food requirements, hippopotamus have substantial impacts on wetland vegetations (Mkanda and Kumchedwa, 1997; Eltringham, 1999; Chansa *et al.*, 2011) and pose physical threats to local communities (Kanga *et al.*, 2011c).

Hippopotamus - human conflicts are reported from several countries in Africa including Ethiopia. Most records referred to as crop damage or losses, attacks on fishermen, destroying fishing nets, attacking canoes and loss of human life (Eltringham, 1999; Admassu, 2007; UNEP-WCMC, 2010). The damages caused by hippopotamus is often far greater than from other common agricultural pests. This is because their raids are unpredictable, more damage per raid, trampling and destroying certain areas of the field (Admassu, 2007).

Even though, hippopotamus cause crop damage and attack human, it is potentially a very important part of African ecosystem and has economical and commercial values on account of its meat, hide and teeth (Eltringham, 1993; Post, 2000; Onyeanusi, 2010). In many countries where hippopotamus is found, the population is declining (IUCN, 2008; Lewison and Oliver, 2008). These declines have been attributed to two anthropogenic activities, i.e. habitat loss as wetlands are converted or impacted by agricultural development (IUCN/SSC, 2005) and unregulated hunting for meat, hide and ivory from its canine and incisor teeth (Eltringham, 1999). These threats are also the most serious problem in Ethiopia, mainly, habitat depletion from agriculture, and conflicts with farmers around rivers and wetlands, conflict with fishermen and water pollution (UNEP-WCMC, 2010). However, there is lack of authentic information on distribution

and population status of hippopotamus in Ethiopia. The level of enforcement of legal protection in Ethiopia is unknown (Lewison and Oliver, 2008).

Extensive environmental changes generate a serious challenge to biodiversity (Cincotta *et al*., 2000). It is apparent that considerable extents of threatened and vulnerable species of conservation concern, like the hippopotamus, utilize agricultural landscapes and conflicts with humans (O'Connell-Rodwell *et al*., 2000). Therefore, considering both the effects of damage caused by wildlife as well as the impacts of mitigating actions on the conservation status of target species are necessary to deal with human - wildlife conflicts (Kanga *et al*., 2011c). It is on this basis, the present study has investigated the nature, intensity and seasonality of human - hippopotamus conflicts.

1.2. Statement of the problem and justification

Conservation of hippopotamus will rely on accurate population estimates, understanding of their habitat use, and evaluations of the impact of human activities on remaining population and hippopotamus - human conflicts (Lewison, 2004). These knowledge gaps are serious problems in Africa, particularly in Ethiopia (UNEP-WCMC, 2010; Kanga *et al*., 2011a). Hippopotamus has not been well studied or monitored in many parts of its ranges, and accurate information on population status in key regions is lacking (Kanga *et al*., 2011a). Existing knowledge on ecological behaviour of hippopotamus is still inadequate and the obtrusive (Dudley, 1998).

Population counts and detailed studies of hippopotamus have not been made in Ethiopian water bodies (Eltringham, 1999; UNEP-WCMC, 2010). This has led to the formulation of the objective of this study. Therefore, the research on population status, ecology and human - hippopotamus conflicts in Boye wetland is crucial in its contribution to address some of the gaps on hippopotamus research in Ethiopian water bodies in general, and in Boye wetland area, in particular.

Boye wetland is one of the wetlands found in Oromiaya National Region, Jimma Zone, near Jimma Town in the east at 7° 39′38″ N and 36°52′14″ E. Grazing, agriculture practice and local brick manufacturing are some of the socioeconomic activities taking place in and around this wetland. It has been highly degraded, and is under the risk of loss due to these socioeconomic

activities, expansion of Jimma town towards the wetland and its conversion for agriculture. In order to mitigate such threats, the present investigation is expected to contribute data on hippopotamus regarding its population status, ecology and conflict with human in this degraded wetland. Hippopotamus has not been studied seriously of this large mammal in this area.

Based on these study problems, the following questions were addressed to fulfill the present study.

- What is the current population status of hippopotamus in Boye wetland?
- What type of plant species contribute to the diet of hippopotamus?
- What are the day time behavioural patterns of hippopotamus?
- What are the human - hippopotamus conflicts in this study area?
- What are the attitudes and perceptions of people (stakeholders) towards the hippopotamus in the study area?

1.3. Objectives

1.3.1. General objective

The general objective of this study was to determine the current population status, ecology and human conflicts of hippopotamus (*H. amphibius*) in Boye wetland, Jimma, southwest Ethiopia.

1.3.2. Specific objectives

- To determine the present population size of hippopotamus in Boye wetland.
- To assess the feeding ecology of hippopotamus in the study area.
- To record diurnal activity patterns of hippopotamus at different time of the day and months.
- To assess the attitude of the stakeholders towards hippopotamus.

1.4. Significance of the study

This study provides first hand information on the persistence of hippopotamus in Boye wetland despite the anthropogenic threats. Information generated from this study will increase understanding of the ecology and behaviour of hippopotamus. It is expected that it will form part

of monitoring for the animal and its habitat and will form the base line information for other researchers in this area.

1.5. Limitation of the study

Even though the work was accomplished successfully, there were limitations. This study was undertaken in a seven month time survey duringt day time field observations. So the study was limited by time and finance, there could have been some bias in the information obtained about population size of the animal and feeding ecology and other behavioural patterns data for night time survey. The study would have been more meaningful, if the study could be included population dynamics by long term investigations. The population trend of the result could not be discussed properly due to lack of documented historical data about the animal in the study area.

2. LITERATURE REVIEW

2.1. Distribution and population status of Common hippopotamus

Hippopotamus is a semi-aquatic artiodactyl of the sub-Saharan Africa (Eltringham, 1999; Okello *et al*., 2005) and there are considerable regional differences in population size and distribution (Eltringham, 1993). Historically, it was widely distributed throughout the Africa region, but most populations have greatly declined in size while others have already disappeared, with the largest populations still remaining in East Africa (Feldhake, 2005; Lewison, 2007; Lewison and Oliver, 2008).

In 2004, the total population of hippopotamus was estimated at 157,000 (HSG, 2004; Chomba *et al*., 2012). This number was compiled by IUCN based on information received from 34 sub-Saharan Africa countries. However, recent estimates suggest that 125,680 - 149,230 *H. amphibius* occurre in fragmented populations in rivers, lakes and other wetlands of eastern, western and southern Africa (Lewison and Oliver, 2008; Théophile *et al*., 2012). Eastern African countries contain the largest populations and form the stronghold for the species, southern African populations are flourishing. Most of the declines are in West African countries with small populations but two East African countries, Uganda and the Democratic Republic of Congo, contain some of the largest populations (Lewison and Oliver, 2008). Hippopotamus was classified by the IUCN as vulnerable (Eltringham, 1999; IUCN, 2008). The population decline 7-20% within 1990-2010 years as a result of exploitation and habitat loss. The projected population reductions will have exceeded 30% over 2010-2040 years (IUCN, 2008; Lewison and Oliver, 2008).

There are five subspecies of *H. amphibious* in Africa (Okello *et al*., 2005; Jones, 2008). Subspecies *H. a. amphibius* is largely found in Sudan, northern Zaire, Ethiopia, Gambia, Tanzania and Mozambique. *Hippopotamus amphibius capensis* is distributed from Zambia south to South Africa, while *H. a. constrictus* is found in Namibia, Angola, southern Zaire and southern Democratic Republic of Congo. *Hippopotamus amphibius kiboko* ranges between Kenya and Somalia, and the *H. a. tschadensis* struggles to survive in West Africa, but does better in Chad and Nigeria.

2.2. Threats and conservation of hippopotamus

The primary threats to hippopotamuses are loss of habitats due to alteration of their essential grazing lands to cultivation, wetland reclamation and growing pressures on fresh water resources (WWC, 2003; Kanga *et al.*, 2011b, c), unregulated or illegal hunting and conflicts with people (Weiller *et al*., 1994; Williamson, 2004; Lewison and Oliver, 2008). The population dynamics of hippopotamus is also influenced by climate change and variability (Eltringham, 1999). Hippopotamuses have long been hunted for their meat and body parts, such as their teeth, bones, hide, tail and feet (Eltringham, 1999; Post, 2000). Lions, Hyenas and Crocodiles are the most common predators of the hippopotamus, particularly of the young or sick individuals (Lewison and Oliver, 2008).

There has been few conservation efforts aimed at protecting hippopotamus habitat and populations specifically. Countries where hippopotamuses are most common have strict hunting regulations in protected habitats, including national parks, reserves, and conservation areas (Lewison and Oliver, 2008). Hippopotamus populations need to be carefully managed in order to avoid confrontations between them and local people. National parks and reserves offer the best opportunities, but there are still places outside national parks where hippopotamus will have to co-exist with people if they are to survive. As the main threat of the species is loss of habitat, conservation measures should be directed towards conserving the environment (Eltringham, 1999).

Hippopotamus was selected for the CITES review of significant trade at the 23rd meeting of the Animals Committee (Geneva, Switzerland, April 2008), due to concerns over declining populations as well as increasing trade. The committee recommended regulation of trade of hippopotamus products, and education and training programmes for stakeholders (UNEP-WCMC, 2010).

2.3. An overview of hippopotamus in Ethiopia

Hippopotamus mainly occurs in Ethiopia within the western parts of the country (UNEP-WCMC, 2010). The species is also abundant between altitudes of 200 and 2,000 m in Ethiopia, where its main strongholds appear to be Omo, Awash and Great Abbi (Blue Nile) Rivers. It also

occurs in most of the larger lakes and smaller swamps and pools. The few that occur in the dry south-east area confined to the Wabi Shebeli and Ganale Rivers. The northern limit of the species is the Setit River (Eltringham, 1999). Very few animals remain in bordering Somalia although some small groups have been reported in the lower Shebeli River and along the Juba River, where they are more numerous (Eltringham, 1999; UNEP-WCMC, 2010).

In Ethiopia, no accurate hippopotamus counts have been made recently, but it is said to be numerous throughout its ranges. The population is thought to be stable at around 5,000 individuals (Eltringham, 1999; UNEP-WCMC, 2010). The shrinkage of hippopotamuses population have been attributed to anthropogenic activities, such as habitat loss as wetlands are converted or impacted by agricultural development and unregulated hunting. These threats are also the most serious problem in Ethiopia. For example, habitat disturbance from riverbank cultivation and conflicts with farmers mainly around the Dabus, Omo and Awash Rivers and the Boyo wetland and with fishermen around Lakes Tana, Awasa, Zeway and Chamo and water pollution due to eutrophication and toxic effluents, including Lakes Awasa, Tana, Chamo and Abaya (UNEP-WCMC, 2010). The level of enforcement of legal protection within Ethiopia is unknown (Lewison and Oliver, 2008).

2.4. Behaviour of hippopotamus

When hippopotamuses are grazing on land, social groups are not apparent (Blowers, 2008). However, during the day two kinds of social groups can be observed. The first group is called school which is dominated by an adult male that holds the territory, contains females and calves. The second group is the bachelor group, consisting mainly of males but possibly with few cows as well (Klingel, 1991).

Hippopotamus has aggressive behaviour toward human beings, and is said to be the most dangerous of wild artiodactyls (Nowak, 1991). A female is particularly aggressive when she has a young calf, while a male may attack (or even kill) any intruder in his territory at times when ‘his’ females are oestrus (Nowak, 1991; Blowers, 2008). Although there is potential to tame them and make them easier to handle (Eltringham, 1999), they are socially schizophrenic and unpredictable in their behaviour (Estes, 1991). Aggressive behaviour can be related to territorial

maintenance, the competitive nature of the social organization, and intense competition for water during the dry season (Estes, 1991; Jones, 2008).

In their reproductive behaviour, males reach sexual maturity at approximately 7.5 years of age and females at 9 years (Martin, 2005). They mate in the water and, eight months gestation, give birth in shallow water as well on land. Twins are rare; the sex ratio at birth is 1:1 (Post, 2000). After the birth of the calf, females separate themselves from the group before returning to water with the calf. But, after 10-14 days they will rejoin the herd (Post, 2000; Martin, 2005; Blowers, 2008). The recorded highest age reached in captivity is 61 years and maximum age is thought to be approximately 40 years in the wild (Eltringham, 1999).

2.5. Habitat requirements and feeding ecology of hippopotamus

As its name suggests, *H. amphibius* is amphibious creature, which has two main habitat requirements: water to rest in during the day and land at night (Lewisson and Carter, 2004). The hippopotamus is found in all types of permanent freshwater habitats, including ponds, rivers, lakes, and waterholes with gently sloping banks surrounded by grazing areas. It avoids extremely dense swampy vegetation and fast-moving waterways with rocky outcrops (Lewson, 2007).

An essential habitat requirement is open water, in which hippopotamus can submerge totally. Hippopotamus prefer shallow, slow moving waters in rivers and lakes, but use mud pits when water sources are scarce. It cannot float, so they require water shallow enough they can stand in and keep their heads above water when resting. They are able to remain under water and hold their breath for approximately 4 - 6 minutes (Eltringham, 1999). They animals avoid forested banks and dense reed beds. They prefer gently sloping shores, which allow for easy access to their grazing areas (Chansa *et al*., 2011). The temperature of the water should vary between 18 - 35^0C. Another ecological requirement constitutes adequate grazing areas on open grassland within a few kilometers of the daytime wetland resting sites (Eltringham, 1993). During these ventures, hippopotamuses follow trails inland to the short grass swards or close-grazed areas of short grasses (Zubkowicz, 2005).

Hippopotamus territories vary in size, depending on seasons and the type of water. Along the shore of a river less space is needed than along a lake. They consist of a narrow strip of water

and adjacent land. Both territory size and length of a bull's tenure vary (Klingel, 1991, 1995). When ecological conditions change, the quality of a territory is likely to change as well, thereby influencing its attractiveness to females and the frequency of their visits (Blowers, 2008).

Hippopotamuses are non-ruminants and their daily food intake ranges between 35 - 50 kg of fresh biomass (Eltringham, 1999; Chansa *et al.*, 2011; Théophile *et al.*, 2012). They nourish themselves only in grasslands of short vegetal species (Eltringham, 1999). Poaceae and Cyperaceae are included in this diet (Noirard *et al*., 2004; Théophile *et al.*, 2012). They feed on grasses, like *Themeda, Heteropogon, Panicum, Urocholora, Cynodon (*Post, 2000; Chansa *et al.*, 2011), and aquatic plants like water cabbage (*Pistia stratiotes*) (Post, 2000). Hippopotamus might be termed an 'area selective' grazer based on the extent to which plant communities occurring within the same grazing surroundings are used. Their preferences reflect local availability (Skinner and Smithers, 1990). Factors determining palatability or acceptability of plants to a grazing animal are complex, and it seems that the different stages of growth of herbage play a key role in the hippopotamus diet (Martin, 2005).

With sufficient grazing opportunistic available, hippopotamus tends to remain close to the water body. However, drought, arid conditions or competition with humans may cause hippopotamus to seek resources some distance from their daily living space (Martin, 2005). The ecological requirements for hippopotamus, therefore, include a supply of permanent water, large enough territory to spread out, and adequate open grasslands within a few kilometers of the daytime resting sites (Eltringham, 1993 and 1999; Martin, 2005).

2.6. Importance of hippopotamus

2.6.1. Economic significance

Hippopotamus has a commercial value on account of its meat, hide and teeth. The global trade in hippopotamus parts includes a wide range of products ranging from skin and leather products to shoes, and raw and carved ivory (Williamson, 2004). The meat is palatable and is readily eaten throughout Africa where it is available. Hippopotamus's meat is a source of animal protein (Post, 2000; Onyeanusi, 2010). The traditional use of the hide for the manufacture of whip and shields has declined but new techniques for its use in the manufacture of shoe leather are being developed (Eltringham, 1999). The international trade in the hippopotamus's upper and lower

incisors and canines is substantial (Weiller *et al.*, 1994). The canine teeth, have always found a ready market amongst craftsmen for the production of carvings or for incorporation into ornaments and other wildlife trinkets (Eltringham, 1999). Some items, like the fat, skin and gallbladder are used in traditional African medicine (Weiller *et al.*, 1994; Post, 2000).

According to Martin (2005), *H. amphibius* could make a significant financial and economic contribution to the wildlife industry in the captivity through uses harvesting for skin and meat and international sport hunting for trophies. The highest valued use for an adult male hippopotamus lies in the sport hunting industry.

2.6.2. Ecological significance

Hippopotamus contributes to the productivity of aquatic ecosystems where it lives. They are regarded as 'the king of the African swamps' (Post, 2000). By contributing the transportation of nutrients from land to water, hippopotamuses are playing a crucial role in African wetland ecosystems. Hippopotamuses improve water flow by keeping channels open (Stuart and Stuart, 1996). It can prevent entire blocking of water courses (Post, 2000). Their regular movements from water pools used during the day to adjacent grazing areas utilized at night create trails, modify river channel geomorphology, and assist in developing micro-topography with consequences for other organisms (McCarthy *et al.*, 1998; Deocampo, 2002). Hippopotamus-grazing effects enhanced vegetation structural diversity and improved spatial heterogeneity associated with the riparian zone, and thus enhanced species diversity and caused compositional shifts in both plants and herbivores at intermediate distances from rivers. Hippopotamus form pond and create water pools that are important refuges for aquatic organisms (Kanga *et al.*, 2011a).

Large amounts of transported vegetation form the nutrient base of a food chain that begins with micro-organisms and culminates in fish, crocodiles and predatory birds (Schwartz, 1996; Post, 2000). Hippopotamus produce huge quantities of dung and defecating both in water and on land (Eltringham, 1993; Post, 2000). This dung enriches the bottom of a watercourse and stimulates the growth of microscopic plant life**.** On the other hand termites use these dung particles and decompose it and brought back into the soil. These recycling of nutrients involve hippopotamus, termites and grasses, and leads to a gradual enrichment of flooded areas (Post, 2000).

Hippopotamuses are often surrounded by many fish species in resting time, which feed on hippopotamus excreta. The micro-organisms and algae also deposited on hippopotamus's skin (Post, 2000). The monogenic flukes (*Oculotrema hippopotamus)* are a parasite to the hippopotamus. It lives on the surface of the eyes of the hippopotamus. Though the parasite is considered to be primarily akin to the fishes and, fishes pick the parasite from the hippopotamus. This important symbiotic relationship which benefits both the hippopotamus and the fish plays some role in fish production in the wild (Onyeanusi, 2010).

Hippopotamus feed on *Pistia stratiotes* (water cabbage) which develops on the excrement of hippopotamus. These leaves are inhabited by numerous water snails, *Pila ovata*, which are -in their turn- eaten by the open-bill stork water bird (*Platalea alba)* (Post, 2000). It also play host to several of aquatic birds, such as cormorants and wagtails resting place on the hippopotamus's back, remove insects and larvae from their host's skin (Post, 2000).

2.7. Human – hippopotamus conflicts

Human – wildlife conflict or negative interaction between people and wildlife is one of the fundamental aspects of wildlife management and it is the most widespread and complex challenge around the world (Fernando *et al*., 2005). It arises from direct and indirect negative interactions, leading to economic losses to agriculture through destruction of crops, human fatalities and injuries, depredation of livestock and retaliatory killings of wildlife (Hill, 1997; Tourenq *et al*., 2001; Treves and Karanth, 2003).

Megaherbivores, such as elephants and hippopotamuses rank among the most problematic and lie at the heart of human - wildlife conflicts **(**FAO, 2009; Kanga *et al.*, 2011c). However Hippopotamuses differ from other megaherbivores in having a dual requirement of daily living space in water and an open grazing range often visited at night (Eltringham, 1999). This requirement affects the manner in which hippopotamus utilize resources and human-hippopotamus conflicts survive in areas where high human population densities and continuous land use changes **(**Kanga *et al.*, 2011c). Loss of habitat, through destruction or modification is undoubtedly the most serious threat facing hippopotamus population (Eltringham, 1993). This is primarily the result of conflicts with agricultural interests (Nowak, 1991; Eltringham, 1993) and increasing livestock numbers (Stuart and Stuart, 1996).

Most hippopotamus - human conflict records are crop damage or losses, attacks on fishermen by destroying fishermen's nets or attacking their canoes, and loss of human life (Eltringham, 1993). Conflicts between hippopotamus and livestock consist of attacks, competition, over grazing grounds, and transfer of diseases. Since the animals use the same grazing grounds, there may be a possible transfer of diseases like rinderpest and anthrax. It is spread by food or water that has been contaminated by the dung of sick animals (Post, 2000).

3. THE STUDY AREA AND METHODS

3.1. Description of the study area

The study was conducted in Boye wetland in Jimma Zone of Oromiya Regional State, southwestern Ethiopia (Fig. 1). Jimma town is the capital and administrative center of the zone, located 353 km south west Addis Ababa. The town is located at 07^0 40′ N and 36^0 60′ E. Boye wetland is one of the wetlands found in this region, located about 4 km east of Jimma town at 7° 39′38″ N and 36°52′14″ E, and covers an area approximately 110.03 hectare. Two major soil types, reddish brown residual soils and alluvial soils of brownish gray and grayish white clay soils are observed in Boye area. The water source of this wetland interconnected to Kitto wetland and join Gilgel Gibe River below the intake point of the water treatment plant of Jimma town. The wetland is permanent type with variable water levels in different seasons. It is continuously fed by ground water and/or spring flow, as well as surface flow during the wet season. Boye wetland is evergreen throughout the year.

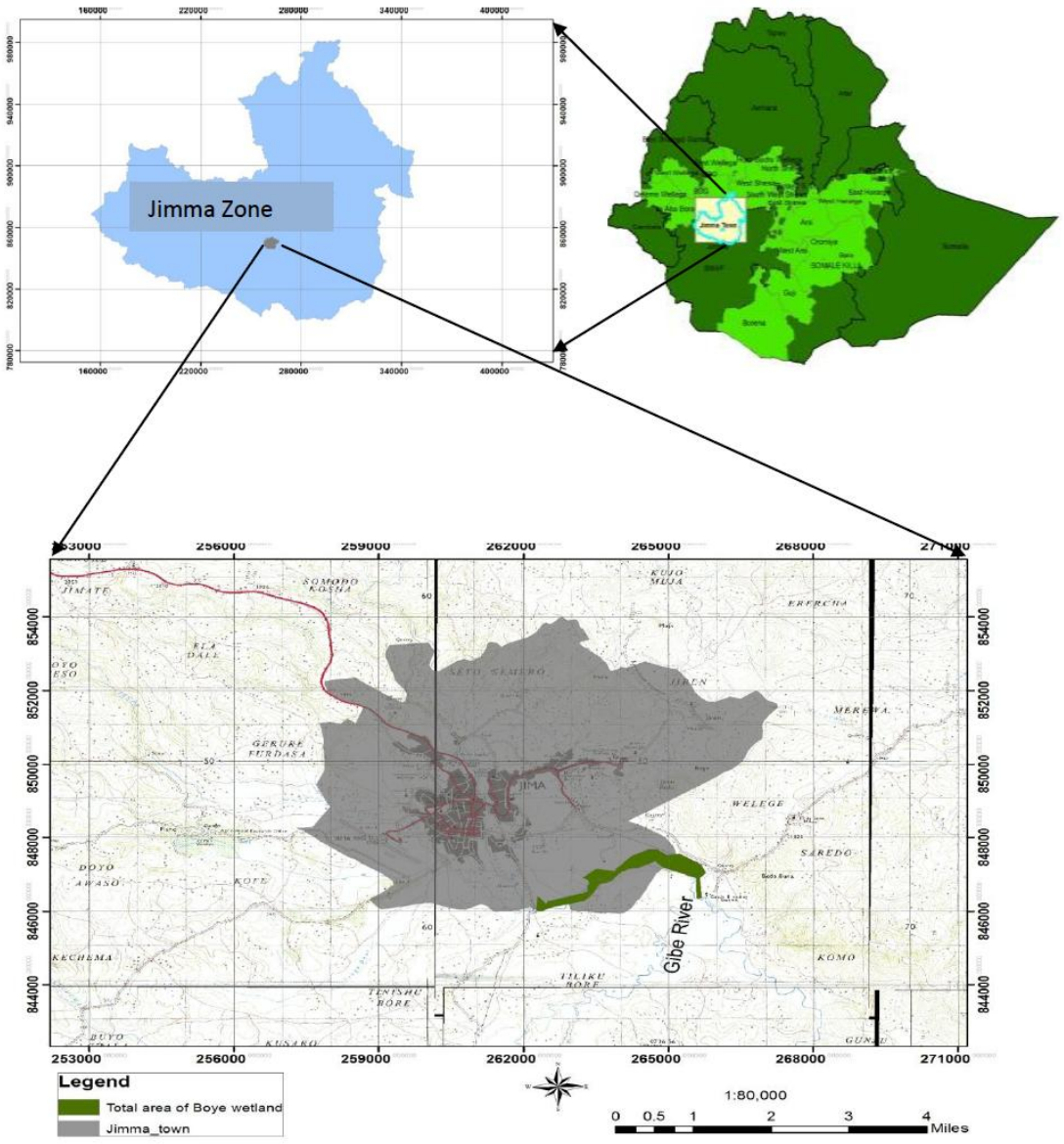

Figure 1: Map of Ethiopia showing the study area

Boye wetland is the areas of flat lands surrounded by small hills having dominant vegetation of Typha grasses, Sedges (Cyperacea*)*, Eucalypts plantation (*Eucalyptus grandis*), Cordia (*Cordia africana*), Acacia species, Celastraceae (*Maytenus arbutifolia),* Finger euphorabia (*Euphorabia tirucalli*) and some other grass species (Fig. 2).

With regarding to fauna, hippopotamus and a greater number of species of birds are found. Yellow-fronted Parrot (*Poicephalus flavifrons)* and Abyssinian longclaw (*Macronyx flavicollis)* are endemic bird to Ethiopia and Black Crowned-crane (*Balearica pavonina)* and Wattled Crane (*Bugeranus carunculatus)* are vulnerable species found in the area (Desta and Mengistu, 2009; Mekonnen and Aticho, 2011). It has also a very rich macroinvertebrate taxa; with Class *Insecta, Gastropoda, Oligochaeta* and *Hirudinea* (Desta, 2006).

Figure 2: Photo of the study area (Photo: Sefi Mekonen, 2013)

The socio-economic activities that take place in the area including livestock grazing, agriculture and mud brick production. Moreover, the ecological potential of this wetland serves as a habitat for a variety of plant, birds and hippopotamus (Fig. 2) and is a water source for human and livestock consumption. But, it has been highly degraded and under the risk of loss due to poor watershed management, solid and liquid wastes disposal from Jimma town, expansion of Jimma town towards the wetland and conversion of this wetland to agriculture practice.

According to Jimma Meteorological Station, the study area receives rainfall ranging between 1416.20 - 1586.70 mm per annum with an average annual rainfall of 1513.28 mm (Fig. 3) having the heaviest concentration from June to September (Fig. 4). The average maximum and minimum temperature is 27.29°C and 11.83°C, respectively, with a mean daily temperature of 19.56°C (Fig. 5) (CSA, 2012).

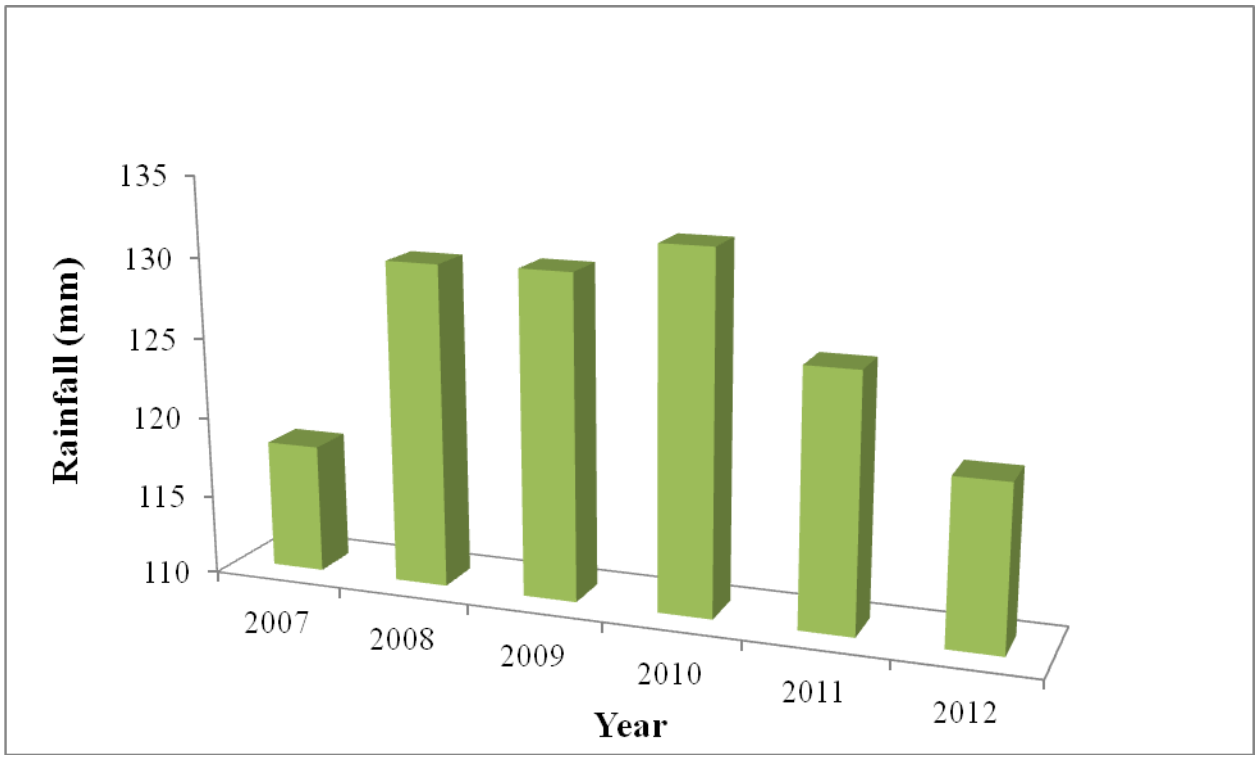

Figure 3: Annual average rainfall of Jimma from 2007 to 2012 (CSA, 2012)

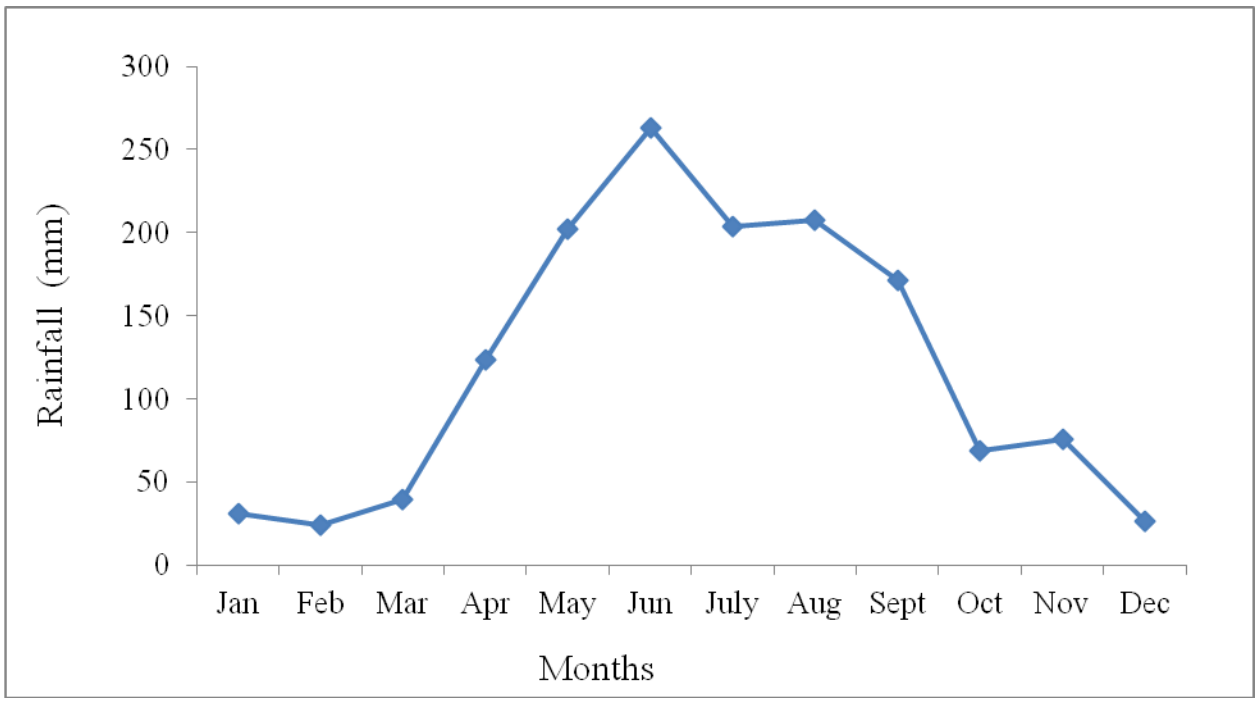

Figure 4: Monthly average rainfall of Jimma for the year 2007 to 2012 (CSA, 2012)

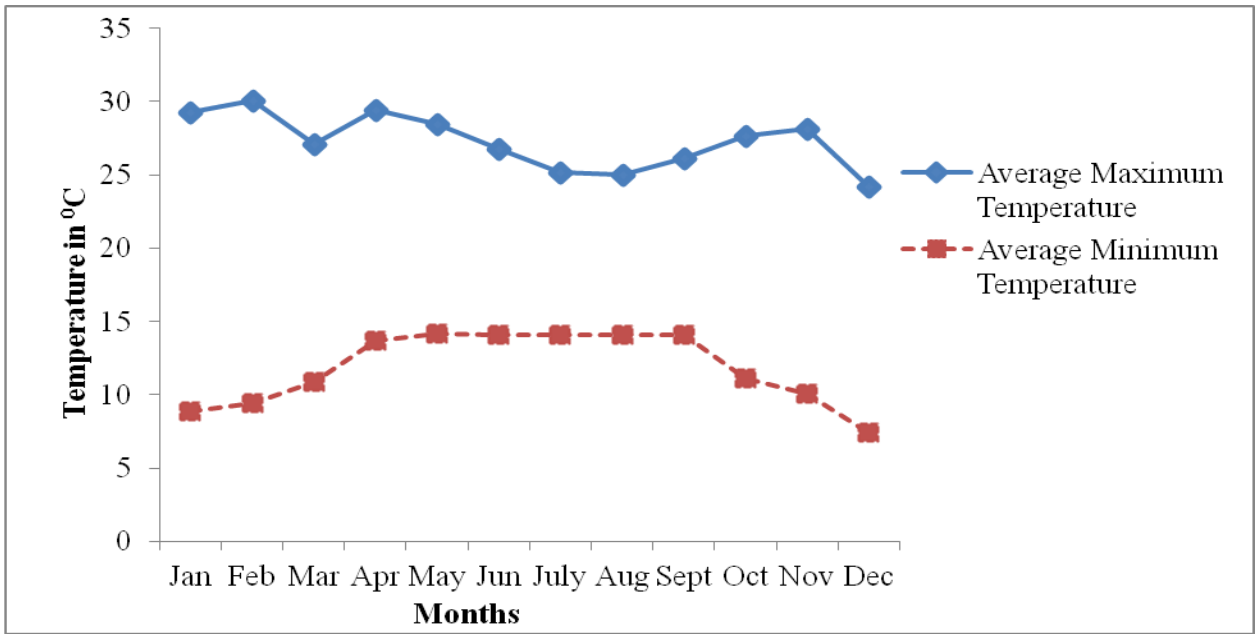

Figure 5: Average monthly maximum and minimum temperatures of the study area from 2007 to 2012 (CSA, 2012)

3.2. Methods of data collection

3.2.1. Preliminary survey

A reconnaissance survey was conducted in the study area before the actual data collection with the help of local people. During this period, all existing and significant information about the study area were gathered. Households found around the study area were assessed for data collection and allocated the questionnaire. Organization and arrangement of the logistic supports, hiring assistants and purchasing field equipment were also done during this period.

3.2.2. Population structure of hippopotamus and its enumeration

Total ground count of hippopotamus specifically by foot was used to gain the accurate population size of this animal in the study area from February to May 2013 at Boye wetland. Additional counting was done from June to August, 2013 at Gibbe River in order to understand the local migration of hippopotamuses from this study area (Boye wetland).

Four observers or counters were deployed to count independently the total numbers of individuals, males, females and young, with the aid of binocular and photograph using digital camera. Counts were compared and repeated until the observers agreed on a count. Observation and counting were conducted twice a month by considering the reproductive behaviour of the animal i.e. after the birth of the calf, females separate themselves from the group before returning to the water with the calf after 10 - 14 days (Post, 2000; Martin, 2005; Blowers, 2008). In order to count this probability of female and calf, fortnightly counting periods have chosen. The survey was performed twice a day, in the morning (08:00 - 12:00 a.m.) and in the afternoon (14:00 - 18:00 p.m.) when hippopotamuses are most visible as they are active and clumped in groups. They tend to move into deeper water where they are more easily overlooked during the mid day (Martin, 2005). Population size survey was not conducted during night time due to lack of logistic support. Average numbers of hippopotamus per day were calculated and monthly means has derived.

To assess population structure, sex and age determination was carried out. Sexes were identified by body size and sexual dimorphic features, while age classes were determined based on body size and their positions and external features. This followed the method used by Tsi *et*

al. (2011) and Chomba (2013). Males have a much bigger body size and massive neck than females (Skinner and Smithers, 1990; Klingel, 1995) and males have broader foreheads than females and the sides of the male heads (around the ears) were darker; in females they were brownish (Skinner and Smithers, 1990). Dominant males keep their ears cocked forward unlike other group members, who tend to keep them angled back along their necks. Also, most of the males stayed in isolation and adult females appeared on the sides of young if she has calf or reside in group. Male and female also distinguished during mating activity and based on external genitalia structure (Chomba, 2013).

Individuals were classified as young and adults. Young have smaller body size and mostly appeared on the sides of the adult females and their heads are smaller. External features of young is wooly and dispersed at the posterior part, while in adults they are course and curly at the muzzle, ears and tail (Tsi *et al*., 2011).

3.2.3. Distribution and seasonal movement

Habitat preferences of hippopotamus were determined from the results obtained from total count in day time resting site and indirect evidence observation for night foraging range. Night time feeding range and the size of resting site were determined and mapped with Arc view. Indirect evidence observations such as droppings, feeding signs, footprints and runways were used as a sigh - post to conduct feeding range in the wetland. Indirect evidences were assessed early in the morning before livestock disturbed the area. GPS was used for marking the locations of these evidences.

Local migration and movement patterns of hippopotamus in Boye wetland and Gibe River were studied based on direct counting data collected through interviews. Counting was done on foot along the river bank of Gibe River from June to August after the animal left Boye wetland. Interviews were conducted with key informant of the community who live around Boye and Gibe River related to the information about the duration hippopotamus lived in Boye and Gibe in a year, seasons (months), migration paths and expected reasons of local movement (see Appendix I). Migration corridors and counting sites were marked using GPS and mapped by using Arc view.

3.2.4. Diurnal activity and event patterns of hippopotamus

Focal animal sampling method was used to study the diurnal activity and event patterns of hippopotamuses, focusing two focal sampled individuals following the method of Altman (1974) and Martin and Bateson (2007) in Boye wetland. A pair of focal animals (an adult male and adult female) was followed and data on their diurnal activities were recorded every 30 minutes with five minutes sampling gap between 07:00-18:00 h except 13:00-14:00 h. Focal animals were selected randomly and clearly identified by distinctive morphological characteristics (skin mark or skin colour) by using binoculars or naked eye. Observations were made for five consecutive days for each four months in Boye wetland. A total of 20 days behavioural observation was done. Observation was facilitated by the animals' preference for short grassy areas and by selecting solitary individual and strategic observation points on the hilly terrain. When the animal remained away for longer than the duration of common activities, it was cancelled from the sample and then duration of the sample period was reduced accordingly.

At each sampling point, the major activities of two individual animals were recorded separately as feeding, moving, resting/standing, mating, barking and yawning. Feeding, moving, resting and mating activities were considered as behavioural activities, while barking and yawning displays were events (Martin and Bateson, 2007; Timbuka, 2012). Events are behavioural patterns of relatively short duration such as vocalization or discrete body movements (Martin and Bateson, 2007), as opposed to behavioural activities which are relatively longer duration such as standing, resting or feeding. Each behavioural activities and events were analyzed independently.

These behavioural categories were defined as: 1) Feeding: as a pattern initiatively involving head movements associated with cutting and ingesting food and searching for feeding sites, 2) Moving: walking on land or swimming in water involving leg movements, changing position and face direction except for feeding and searching feeding sites, 3) Resting: standing or lying in the water without leg movements and position change. In this state, the focal animal was immobile and may be passively touching other individuals. 4) Mating activity: was the actual event of copulation after courtship. 5) Barking or vocalization: Any vocals like snorting, underwater bubbles or wheeze-honk. 6) Yawning: a warning signal or threat display given by hippopotamus, mouth is wide open showing the huge canine tusks (Jones, 2008; Timbuka, 2012).

3.2.5. Feeding ecology of hippopotamus

Methods used to determine the feeding and habitat association of hippopotamuses included analyzing their habitats, and collecting and identifying the plant species consumed by hippopotamus. The plant species consumed by hippopotamus were studied by examination of fresh feeding signs that was observed from foraging area and in the crop lands during patrol early in the morning after the passage of the animal (Theophile *et al.,* 2012). In addition to feeding sign observations, the diet of hippopotamus was carried out by direct feeding observation when the animal eat in day time. The food plants were collected, pressed and then identified with help of a taxonomist in Botanical Herbarium in Jimma University. The percentage of feeding preference of a plant species was determined by equation 1 (Theophile *et al.,* 2012).

$$CS_i = \frac{FS_i}{\sum_{i=1}^{n} FS_t} \times 100$$ ----------Equation 1

Where CS_i = Contribution of Species one, FS_i = Frequency of species one FS_t= Frequency of total collected species.

3.2.6. Tracks and footprints of hippopotamus

Footprint distance was measured from the outer edge of the wrinkled imprint to the middle of the hind-footprint hole from the track of hippopotamus following the method of Elephant's footprint measurement (Western *et al*., 1983; Whyte, 1996). The circumferences of footprint holes were also measured and determined the perimeter or circumference of the hole in the run ways of the animal. Mean of footprint distance and circumferences were obtained from four consecutive footprints at one flatland runway or track as a sample. The distance between consecutive footprints were measured and derived the mean value of footprint length by dividing the sum value of three distances to three at one sample site.

3.2.7. Human impacts on the habitat and hippopotamus

The impacts of human activities and survival of hippopotamus in the study area were assessed in field observations and questionnaires. Grazing area overlaps between hippopotamus and livestock in Boye wetland was conducted by counting the type and numbers of livestock grassed on hippopotamus's resting site and foraging area. The negative responses of human to the presence of hippopotamuses (i.e. chasing, noise making and trying to kill) were recorded in a data sheet.

3.2.8. Questionnaire survey

Attitudes of the society living around the wetland towards hippopotamus were assessed using semi - structured questionnaire. The questionnaire has 23 both open and close-ended questions (Appendix 2). People were interviewed by two native speakers (Amharic and Afane Oromo). Gender and age of the respondents were made proportional.

3.3. Data Analysis

Statistical package software SPSS version 16.0 was used to analyze the data. One way ANOVA was used to compare population size of the animal in Boye wetland and Gibe River. Population structure and variations in behavioural patterns between males and females were tested using t-tests. Descriptive statistics were used to calculate frequencies, and to allow cross-tabulations. Proportions of respondents were calculated for social parameters to compare different variables related to different questions. Chi-square tests for selected variables were used to determine the degree between dependence and independent variables and to test the significance of some sociological parameters and attitudes of local communities towards the hippopotamus. All over, 0.05 level of significance was used as the criterion for comparison of the mean and confidence interval at 95%.

4. RESULTS

4.1. Population structure

The count of hippopotamus in the Boye wetland during the present study is given in table 1. The average of 14.75 ± 1.89 hippopotamus was recorded in Boye wetland before migrating to Gibe River. The highest number of hippopotamus recorded was 16 during March and April; however there were no observation of hippopotamus in the month of June, July and August. The population size of hippopotamus had a statistical significance difference between months (t= 15.58, df= 3, P=0.001).

Table 1. Mean monthly population structure of hippopotamus in Boye wetland.

Month	Population structure			Total
	Male	Female	Young	
February	5	7	3	15
March	5	7	4	16
April	5	7	4	16
May	4	5	3	12
Average				14.75 ± 1.89

The population composed of 19 (32.20%) males, 26 (44.07%) females and 14 (23.73%) young. Adults constituted 76.27% and young 23.73% of the total population. Out of the adult individuals, male and females represented 42.22% and 57.78%, respectively. There was no significant differences among the sex and age groups during this study at F = 0.683, df= 2, P = 0.518 level of significance. The sex and age ratio of hippopotamus are given in table 2. The sex ratio of male to female during all the study months was 1.00:1.37. The young to adult individual ratio was 1.00:3.21. But, young to female ratio was 1.00:1.86.

Table 2. Monthly sex and age ratio of hippopotamus

Month	Sex and age ratio		
	Male : Female	Adult :Young	Adult female: Young
February	1.00:1.40	4.00:1.00	2.33:1.00
March	1.00:1.40	3.00:1.00	1.75:1.00
April	1.00:1.40	3.00:1.00	1.75:1.00
May	1.00:1.25	3.00:1.00	1.67:1.00

4.2. Distribution and seasonal movement

Hippopotamuses were not distributed across habitats in Boye wetland. They were restricted to 0.098km^2 resting site area of open, slow moving water, in which they submerge as shown figure 6. The feeding range area of hippopotamus in Boye wetland was 0.099km^2 in addition to day time resting site (Fig. 7).

Figure 6: Hippopotamuses in Boye wetland (photo: Sefi Mekonen, 2013)

Out of the 24 respondents, 19 (79.17%) remarked that the same groups of hippopotamus are seasonally migrating between Boye wetland and Gibe River. Of these, 71.43% and 28.57% respondents stated that hippopotamus live in Gibe River for five months (from June up to October) and six months (June up to November) respectively, then move all groups to Boye wetland. However, 20.83% of the respondents reported that the Gibe's and Boye's hippopotamuses are different groups and they did not know from where the hippopotamus immigrate in to Gibe River and where to emigrate in different season. All (100%) of respondents confirmed that hippopotamus have not lived in Gibe throughout the year.

The migration routes had two probabilities (Fig. 7). Among the respondent, 78.57% described that the hippopotamus move at night through dry land or crop lands, while 21.43% stated that the animal migrate following the water flow to interconnection edge of Boye wetland and Gibe River.

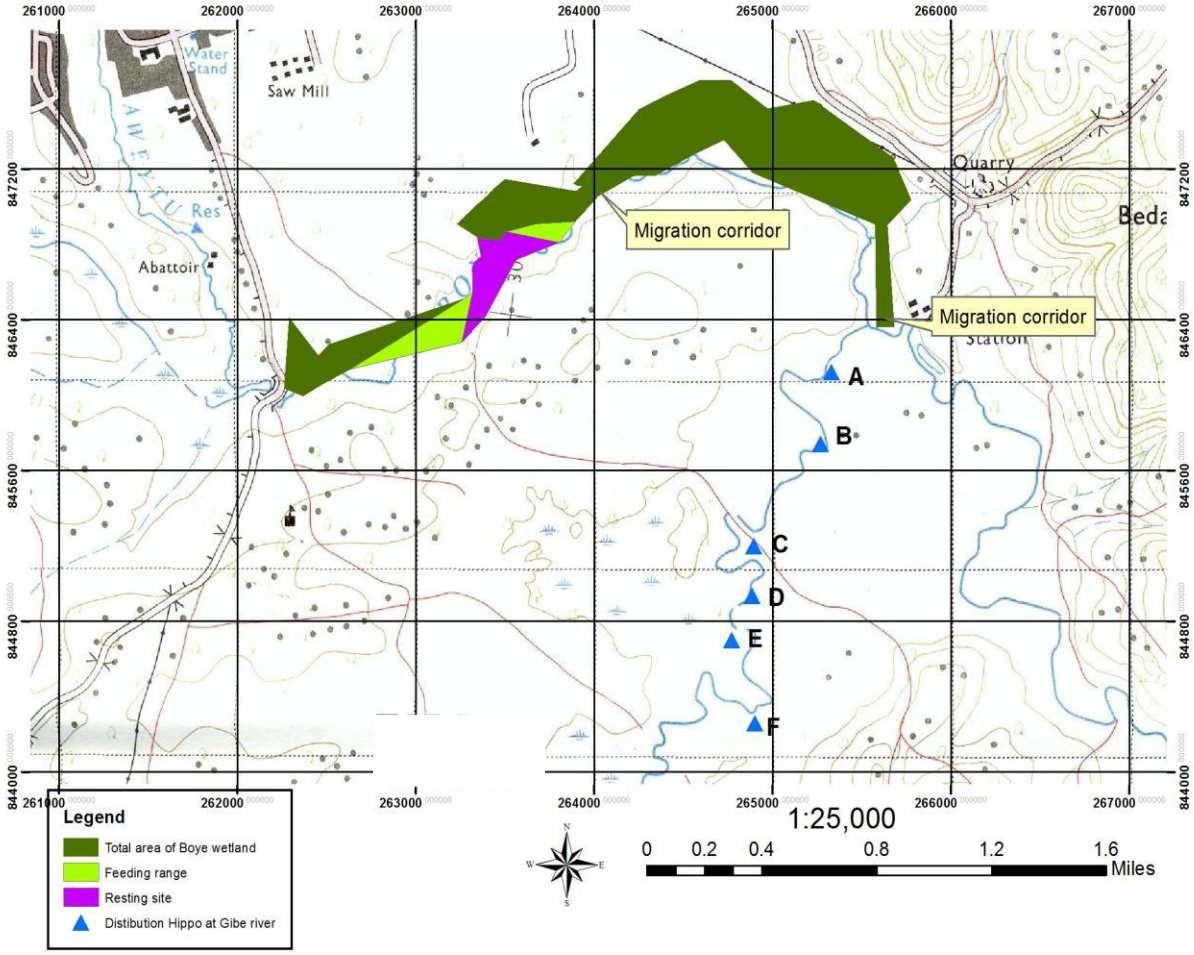

Figure 7: Distribution and migration corridors of hippopotamuses in Boye wetland and Gibe River

According to the field observations, the hippopotamus population was constrained at one day time resting area in Boye wetland up to May. However, in Gibe River there were the mean of 13.67 ± 0.58 hippopotamuses recorded at six counting sites along the river bank of Gibe River from June up to August 2013 (Table 3 and Fig. 7). The population size of hippopotamus had no significant difference between Gibe and Boye ($F=0.881$, $df=1$, $P=0.391$).

Table 3. Total individuals of hippopotamus per month counted in each of the counting sites in Gibe River.

Month	No. of hippopotamus recorded at each counting sites						Total
	A	B	C	D	E	F	
June	3	-	5	-	2	3	13
July	-	3	5	6	-	-	14
August	-	6	2	-	2	4	14
Average ±SD	1.0±1.73	3±3	4.0±1.73	2.0±3.46	1.33±1.15	2.33±2.08	13.67 ± 0.58

4.3. Diurnal activity and event patterns of hippopotamus

A total of 1368 behavioural records were made from an adult male and female focal sampled hippopotamuses. Of these 647 were diurnal activities such as feeding, moving, resting and mating and the rest 721 were barking and yawning events. As shown table 4 adult hippopotamuses were spent on 19.63% feeding, 34.16% moving, 42.50% passive (lying and standing) and 3.71% mating of their behavioural activities. However, 51.18% and 48.82% of behaviours were displayed barking and yawning events, respectively.

Table 4. Diurnal activity and event records of male and female hippopotamus

Sex	Behavioural Activities				Total	Behavioural Events		Total
	Feeding	Moving	Resting	Mating		Barking	Yawning	
Male	40	104	148	12	304	150	163	313
Female	87	117	127	12	343	219	189	408
Total	127 (19.63%)	221 (34.16%)	275 (42.50%)	24 (3.71%)	647	369 (51.18%)	352 (48.82%)	721

4.3.1. Comparison of activity and event budgets between male and female hippopotamus

Time allocated to different activities and events by adult female and male over the entire study period are provided in table 4. Out of 647 and 721 behavioural activities and events respectively, male hippopotamuses displayed less percent (46.99% and 43.41%) of behavioural activities and events than females (53.01% and 56.59%), respectively. Females perform more behavioural activities than males (Fig. 8).

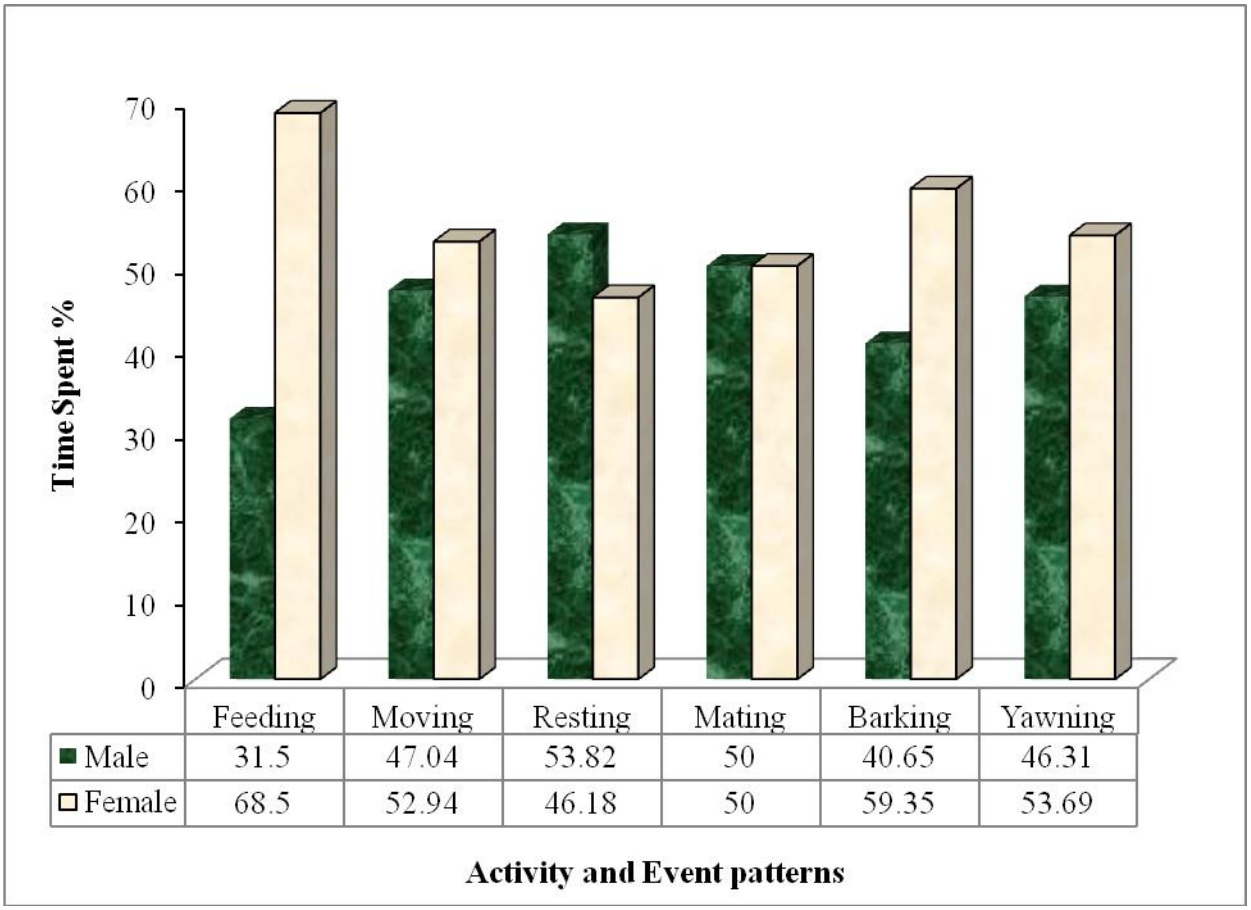

Figure 8: Comparison of diurnal activity and event patterns between male and female hippopotamus

There were no major variations in the percentages of time spent observed for various activities at different time of the day between male and female. Feeding and moving behavioural displays showed two peaks, one in the early morning between 07:00-09:00 h and the other in the late afternoon between 16:00 and 18:00 h. Resting or lying down was highly pronounced during the hottest time of the day or at noon hours during 11:30 to 15:30h.

The least activity of male and female was mating. Mating of hippopotamus was by the male climbing on the back of the female in the water (Fig. 9). Mating was recorded during 08:00-11:00h (41.67%) and during 15:00-17:00h (58.33%) in both male and female focal animals in the month of April.

Figure 9: Mating activity of hippopotamus in Boye wetland (Photo: Sefi Mekonen, 2013)

Barking and yawning were observed at any time of the day in both male and female, but mostly in the afternoon hours. Yawning characters of the animal raising head opening of the mouth forward (Fig. 10). Following yawning, they repeatedly open and close their mouths with low grunt and more head bobbing. Yawning characteristics of male and female hippopotamus were similar.

Figure 10: Yawning characteristics of hippopotamus in Boye wetland (Photo: Sefi Mekonen, 2013)

4.3.2. Monthly variations in activity and event budget

Feeding among male hippopotamus was most frequent in April followed by May, whereas February and March were least frequent feeding months (Fig.11A). May was the month with the highest moving recorded. Moving in February and April were equal. March recorded the highest resting, least moving and barking among male hippopotamus. The highest barking of male hippopotamus was recorded in April. Maximum yawning was recorded in February while minimum in March and May.

Feeding among the female was least in February than in all other months, while it was at its highest in April followed by May. Maximum moving was in April, followed by May and minimum was in February followed by March. Resting was higher in February, followed by March and May and least was in April. Barking in the female hippopotamus was most frequent in February and May, followed by April. Barking was least recorded in March. Maximum

yawning of female hippopotamus was in April followed by February, while minimum yawning was in March followed by May (Fig. 11B).

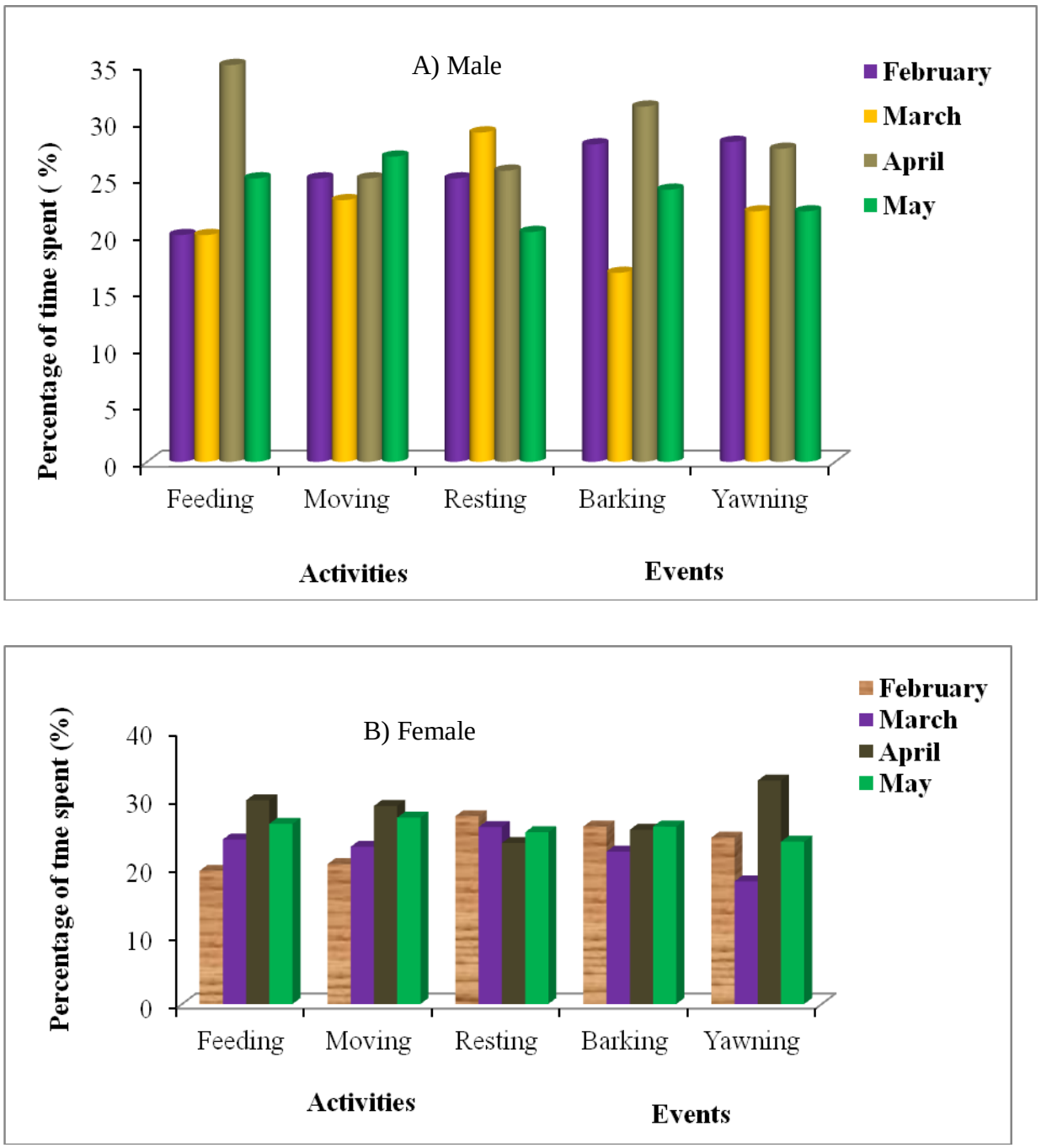

Figure 11: Monthly variations of activities and events of male and female hippopotamus

4.4. Feeding ecology

A total of 26 plant species belonging to 10 families (not including crops) were identified as food item of hippopotamus (Table 5). Out of these, 15 species were recorded in both feeding signs observation and direct feeding observations, while the remaining 11 species were only seen feeding signs or bites. The contribution of the diet was from the family Poaceae (38.46%), Polygonaceae (15.38%); Amaranthaceae, Apiaceae, Asteraceae and Onagraceae (7.69%, for each), and Commelinaceae, Cyperaceae, Lamiaceae and Typhaceae (3.85%, for each). There were a total of 959 observations of these 26 species of plants during feeding sign observation. Based on the overall percentage contribution, *Eriochloa fatmensis* was the most consumed plant species, which accounted for 11.68%. T*ypha latifolia* ranked second (9.91%), *Echinocloa pyramidalis* ranked third (9.59%), followed by *Cynodon dactylon* (8.45%) (Table 5). *Ludwigia stolonifera* (0.31%), *Alternanthera sessilis* (0.42%) and *Pennisetum thunbergii* and *Ludwigia erecta* (0.52%, each) were the least recorded diet of hippopotamus.

Table 5. List of plant species and percentage of the diet of hippopotamus

Family	Species	Frequency of observation	Percentage (%)
Amaranthaceae	*Alternanthera nodiflora*	6	0.63
Amaranthaceae	*Alternanthera sessilis*	4	0.42
Apiaceae	*Hydrocotyle mannii*	64	6.67
Apiaceae	*Oenanthe palustris*	9	0.94
Asteraceae	*Guizotia arborescens*	10	1.04
Asteraceae	*Partheniuum hysterophorus*	7	0.73
Commelinaceae	*Commelina benghalensis*	23	2.40
Cyperaceae	*Cyperus rigidifolius*	69	7.19

Lamiaceae	*Orthosiphon schimperi*	11	1.15
Onagraceae	*Ludwigia erecta*	5	0.52
Onagraceae	*Ludwigia stolonifera*	3	0.31
Poaceae	*Eriochloa fatmensis*	112	11.68
Poaceae	*Echinocloa pyramidalis*	92	9.59
Poaceae	*Cynodon dactylon*	81	8.45
Poaceae	*Echinochloa crus-pavonis*	79	8.24
Poaceae	*Cynodon plectostachyus*	73	7.61
Poaceae	*Leptochloa rupestris*	72	7.51
Poaceae	*Sacciolepis Africana*	63	6.57
Poaceae	*Festuca abyssinica*	10	1.04
Poaceae	*Eleusine floccifolia*	9	0.94
Poaceae	*Pennisetum thunbergii*	5	0.52
Polygonaceae	*Persicaria decipiens*	23	2.40
Polygonaceae	*Persicaria attenuate*	17	1.77
Polygonaceae	*Persicaria glabra*	9	0.94
Polygonaceae	*Persicaria senegalensis*	8	0.83
Typhaceae	*Typha latifolia*	95	9.91
Total		959	100%

There were a total of 310 direct feeding observations of hippopotamuses from 11 plant species (Table 6). Of these, *Eriochloa fatmensis* contributed high percentage (23.22%) of the diet, followed by *Typha latifolia* (16.77%). In addition to the species found in the wetland, Maize (*Zea mays*), Sugar cane (*Sacchurum officinarum*), Banana (*Musa paradisica*) and Teff (*Eragristis teff*) were crops observed heavily consumed by the hippopotamus in the farmland.

Table 6. Diet percentage of plant species collected in direct feeding observation of hippopotamus

Plant species	Frequency of observation	Percentage (%)
Commelina benghalensis	19	6.13
Cyperus rigidifolius	24	7.74
Echinocloa pyramidalis	36	11.63
Eriochloa fatmensis	72	23.22
Hydrocotyle mannii	21	6.77
Leptochloa rupestris	23	7.42
Oenanthe palustris	15	4.84
Persicaria attenuate	3	0.97
Persicaria decipiens	16	5.16
Sacciolepis Africana	29	9.35
Typha latifolia	52	16.77
Total	310	100%

4.5. Tracks and footprints of hippopotamus

Hippopotamus reached their pastures along well-worn tracks, as is shown in figure 12. Mud and grasses were stirred up and soil was unconfined into the water and caused high overhang. Hippopotamus's footprints were very wide and trampled and almost tunnel-like (Fig. 13). There were a total of 17 sites of tracks examined, from each 68 and 51 number of footprint circumferences and footprint distances were measured, respectively. The average value of all 17 sample sites of footprint was 81.00 cm and 84.94 cm circumference and distances respectively. There were significant difference among mean values of footprint distance ($t=35.924$, $df= 16$, $P=0.00$) and circumferences ($t=33.641$, $df= 16$, $P=0.00$) measurements per sampling sites. The mean value of circumferences and distance of footprints were positively correlated ($r= 0.795$, $P= 0.00$). 59.75cm and 70.67cm were the average minimum value of footprint circumference and length, respectively recorded at sample site 7, while 94.25cm and 103.67cm were the average maximum records of footprint circumference and distance, respectively at sample site 15 (Fig. 14).

Figure 12: Tracks of hippopotamus

Figure 13: Footprints of hippopotamus

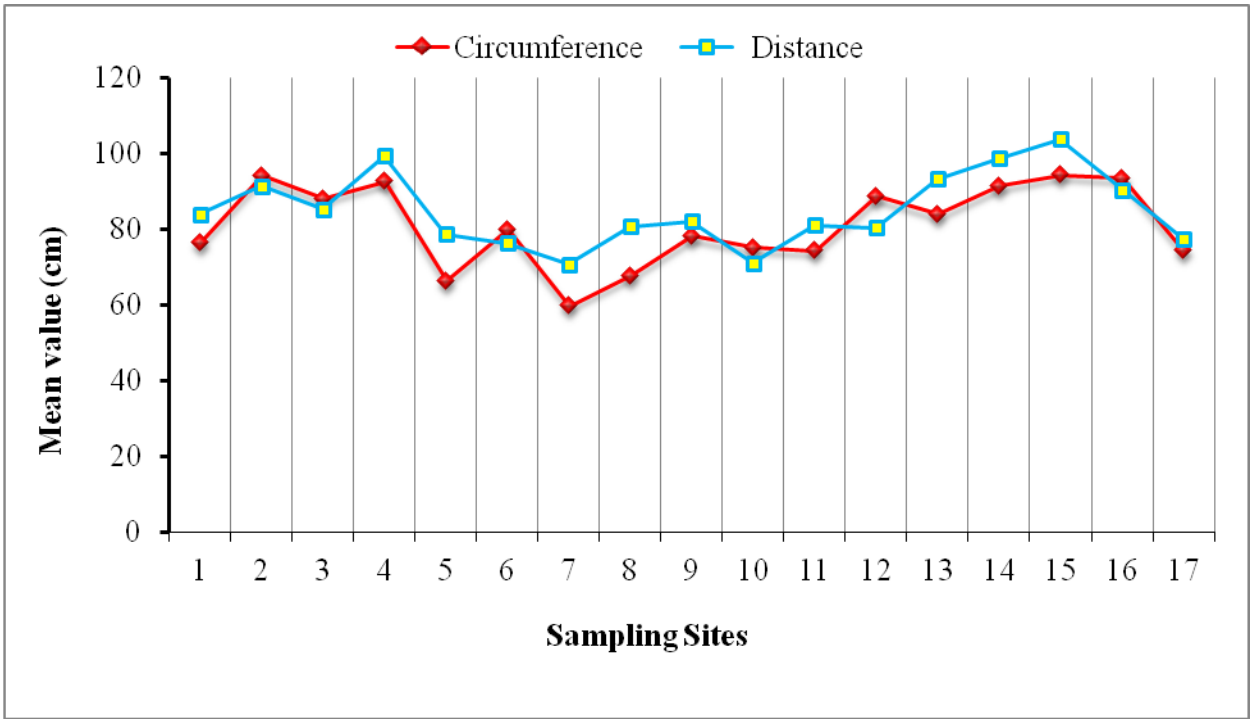

Figure 14: Mean value of the distance and circumference footprints of the hippopotamus

4.6. Human impacts on the habitat of hippopotamus

Activities of people in the habitats of hippopotamus were observed the major direct threat (Fig. 15). Direct threats were the activities of people directly on the animal such as negative response to the hippopotamuses (such as making noise, chasing and killing) and cutting and firing grasses. Settlement, agriculture expansion, collecting of grass, overgrazing by livestock, mud's brick manufacturing and flood sedimentation from Jimma town to Boye wetland were the most crucial threats directly to the Boye wetland that in turn will affect hippopotamus.

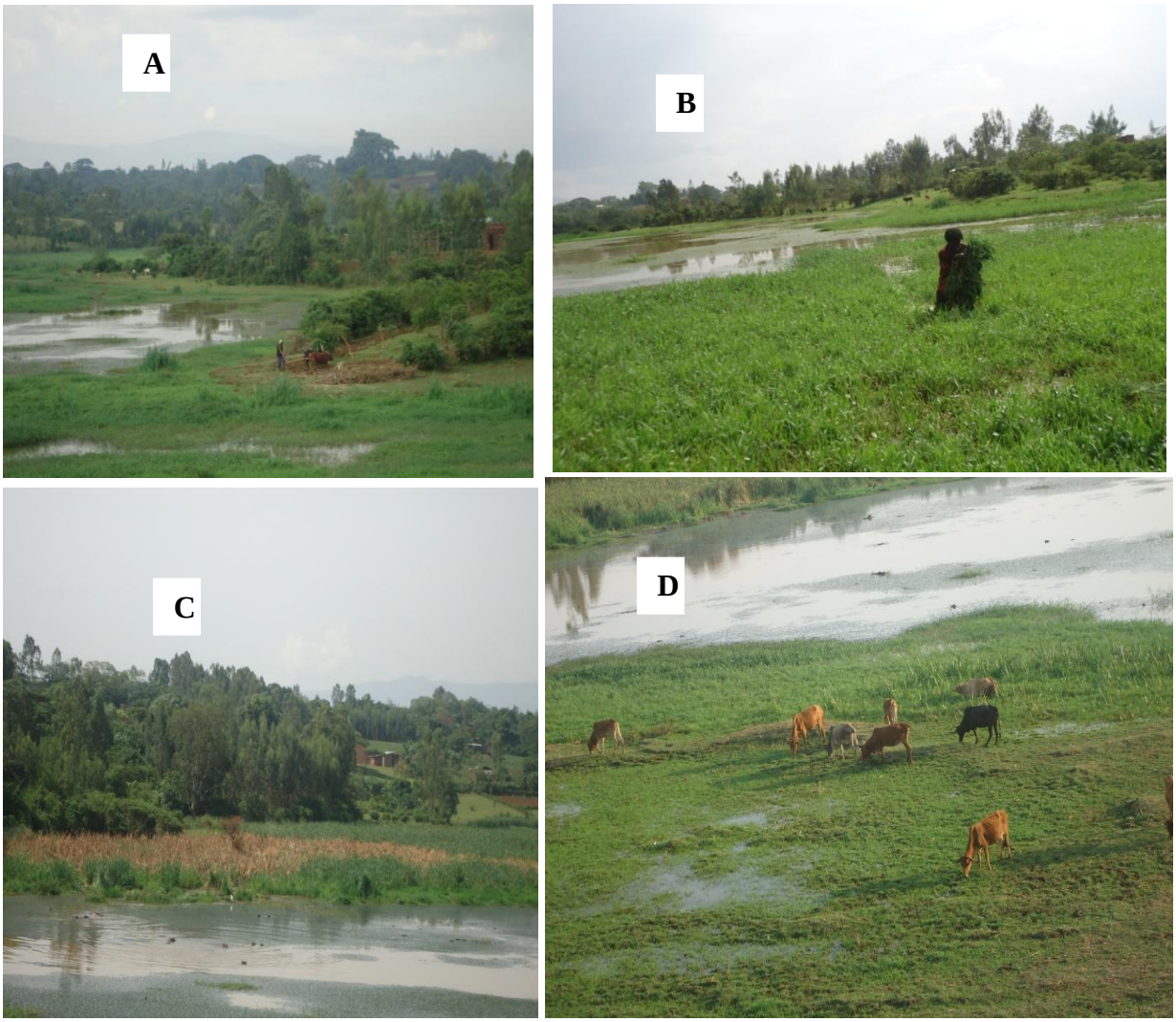

Figure 15: Major threats of hippopotamuses: (A) farming, (B) collecting grasses, (C) firing of grasses, (D) grassing by livestock (Photo: Sefi Mekonen, 2013).

There were 297 local people recorded who had respond negative responses to hippopotamus when they have seen the animal. Of these, 148 people were making noise, 99 were chasing and the rest 50 people were tried to quite or trying to kill hippopotamus (Fig. 16).

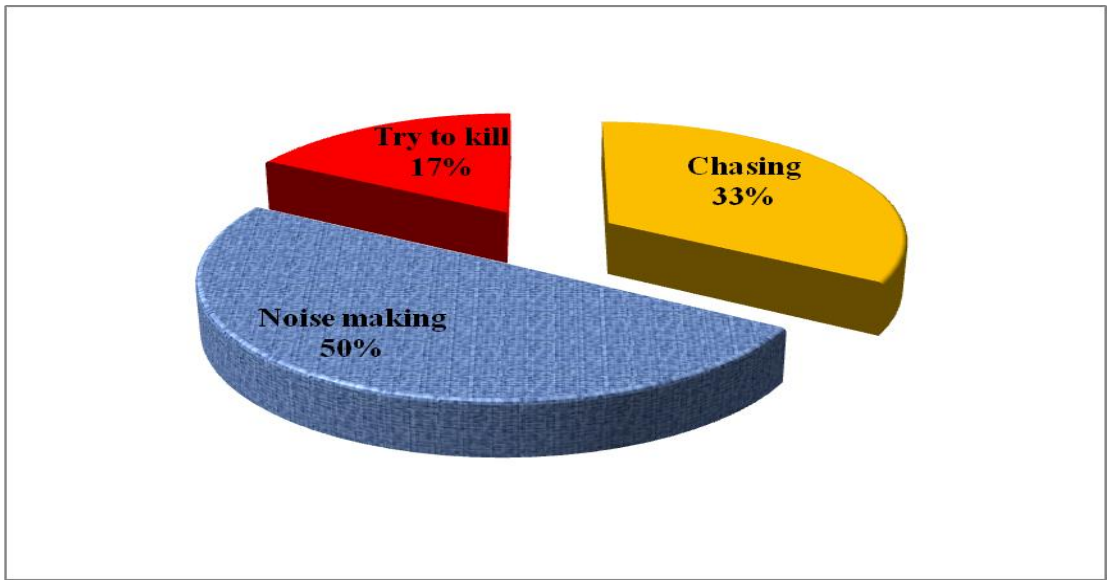

Figure 16: Negative response of local people on hippopotamus

Figure 17: Chasing of hippopotamus by local people (Photo: Sefi Mekonen, 2013)

Boye wetland is an unprotected area and the local community uses the area for their livestock grazing throughout the year. More livestock observed was cattle, followed by horse, donkey and sheep which constituted an average of 351, 178, 20 and 16 individuals, respectively. During the present study, 268 local people were seen cutting and collecting grass from the area where hippopotamus graze and rest during the day time.

Encroaching this wetland by people for construction of houses was also noticed. Most of the houses found around the study area were newly constructed with mud and wood. Jimma town expansion and waste disposal were also revealed as a threat to this fragile ecosystem. Seweage from Jimma town is draind down in to the wetland through three main directions and settling in this wetland. There were also small-scale brick production sites in Boye wetland. These areas were highly degraded due to excavation of soil for bricks and cutting of eucalypts has processing.

4.7. Questionnaire Survey

4.7.1. Demographic characteristics of respondents

There were a total of 110 respondents in the questionnaire survey. Demographic characteristics showed that 62.7% were males and 37.3% were females (Table 7). The number of males was significantly higher than females ($\chi 2 = 7.127$, df = 1, P =0.008). Among the respondents, 85.5% were 11 to 50 years old, while 24.5% were older than 51 years. There was no significant age difference (x^2 =8.28, df=5, P = 0.141) and significantly in educational status (x^2= 14.57, df= 4, P= 0.006 between male and female respondents. Most respondents (26.4%) were illiterate, while 23.6% were able to read and write, 25.5% had primary education, 13.6% had secondary education and 10.9 % had beyond secondary level of education. There was a significant difference ($\chi 2$ =11.364, df = 4, P =0.023) in the educational status among the respondents.

Table 7. Background of the respondents involved in questionnaire survey

Age groups	Sex of individuals		Educational background, %				
	Male	Female	Beyond 2nd ry school	2nd ry school	Elementary school	Read and write only	Illiterate
11-20	14	10	12.5	29.2	54.2	4.2	0
21-30	12	9	42.9	14.3	23.8	9.5	9.5
31-40	15	13	0	14.3	17.9	35.7	32.1
41-50	17	4	0	4.8	14.3	49.9	38.1
51-60	3	4	0	0	28.6	0	71.4
>61	8	1	0	0	0	44.4	55.6
Total	69	41	10.9	13.6	25.5	23.6	26.4

Out of the respondents, 68 (61.8%), 36 (32.7%) and 6 (5.5%) respondents have had 5-7, 2-4 and 8-10 family size, respectively. There was a significant difference (X^2 =52.436, df = 2, P =0.00) in between family size. The majority (43.6%) of the respondents had lived for 1-5 years, however there was a significant difference (χ^2 =90.40, df = 5, P =0.00) among the respondents (Table 8).

Table 8. Time span of respondents lived around the study area

Time span of living (years)	No. of respondents	Percent %
1-5	48	43.6
6-10	29	26.4
11-15	22	20
16-20	4	3.6
21-30	2	1.8
More than 31	5	4.5
Total	110	100%

4.7.2. Household economy

Most 98 (89.1%) of the respondents were having livestock. Of these, all (100%) local communities were using this wetland for managing their livestock. In addition, 69 (70.4%) respondents used grass throughout the year (10-12 months), 27 (27.6%) respondents used for 7-9 months and the remaining 2 (2.0 %) respondents used grass for 4-6 months in the study area. The livestock were dominated by cattle (803), followed by horse (193), sheep (107), donkey (79) and goat (41).

The crop land size of the surveyed respondents around the study area was ranged from 0 to 2.5 ha. 23.6% respondents were with no crop land, while 41.67% had 0.1 to 0.5ha, 25% had 0.6-1.0ha, 14.3% had 1.1 to 1.5ha, 11.9% had 1.6 to 2.0ha and 7.1% had 2.1 to 2.5ha crop land. The major crops or vegetation are Maize, Teff, bean, potato, Taro, Sugar cane, Coffee, Banana, Qocho.

4.7.3. Attitude and perception of local community on hippopotamus

Majority (47.3%) of the respondents were opposed the existing of hippopotamus, while 37.3% and 15.5% had positive and neutral attitudes, respectively (Table 9). However, there were a significant difference between educational status ($\chi2 = 49.805$, df = 8, P =0.00) and between age ($\chi2 = 44.593$, df = 10, P =0.00) in the attitude of local people towards hippopotamus, while between sex of respondents ($\chi2 = 1.377$, df =2, P =0.502), length of time living in the area ($\chi2 = 11.532$, df= 10, P= 0.318) and family size ($\chi2= 2.91$, df= 4, P= 0.682) had no significant difference in the attitude of the local people towards hippopotamus. Younger generation (11-30 year) showed positive attitude towards hippopotamus than old age groups (age >31 years). Relatively better-educated groups (elementary 11 (26.83%), secondary 13 (31.70%) and beyond secondary 10 (24.39%)) had more positive attitude than non-educated groups (illiterate 5 (12.20%) and only read and write 2 (4.88%) group). 38 (34.50%) of respondents want to involve in management or conservation of hippopotamus whereas 72 (65.5%) respondents have no interest in conservation activity of the animal.

Table 9. Attitude and perception of respondents towards hippopotamus

Response category	No. of respondents	Community perception
Positive	41 (37.3%)	-Potential for visitors (foreign) -Recreational value for local people -Material production (Material culture) -Educational and ecological value
Negative	52 (47.3%)	-Cause of crop damage - Over grazing the wetland -Problem faced on human and domestic animals -Its benefits are much less than problems
Neutral	17 (15.5%)	

Most of the respondents (65.45%) remarked that the number of hippopotamus in Boye is declining, but 27.27% were unsure whether the hippopotamus is increasing or decreasing, 4.55% recommended as stable and 2.73% stated as increasing. Among respondents, 56 (50.9%) did not believe their activities have a factor on hippopotamus numbers and its habitat, while 54 (49.1%) respondents considered their threats on the animal or its habitat. However, there was no significant difference (X^2 =6.188, df =3, P =0.103) between population status of the animal and understanding of respondents on their activities had a factor on the animal in the study area.

Regarding threats, 22.2% agriculture expansion, 27.8% settlement, 18.5% increasing of grass collectors, 24.1% overgrazing or competition with livestock and 7.4% were killing and chase of the animal. From the total respondents, 28 (25.5%), 41 (37.3%), and 41 (37.3%) respondents had an opinion, the present size of the wetland is increasing, decreasing and no change respectively, while the opinion of respondents to the size of the wetland had no a significance differences in sex (X^2= 0.508, df= 2, P= 0.776), in age (X^2= 14.403, df= 10, P= 0.155), in family

size (X^2 = 6.301, df= 4, P= 0.178), in educational status (X^2 =13.548, df =8, P= 0.094) and in time length live the respondent around the study area (X^2 =9.739, df= 10, P= 0.464).

4.7.4. Value of the hippopotamus in the study area

Among the respondents, 40 (36.4%) stated that hippopotamus had no value and the continued existence of this animal had a negative impact on their livelihood, while 70 (63.6%) respondents stated that hippopotamus was important. Reasons given for the importance of hippopotamus were recreational value 17 (24.3%), production of cultural materials from the skin of hippopotamus 6 (8.6%), attracting visitors 2 (2.9%), and the rest (64.2%) stated a combination of the above values and educational value and important for future generations as a natural resource

The recreational value of hippopotamus for local communities and for visitors from Jimma town was observed during the field survey. On holydays (especially, Sunday) foreign and local people were visiting Boye and enjoyed with wetlands and its scenic beauty. During this study period, there were 23 visitors in the study area.

4.7.5. Human- hippopotamus conflict

Most respondents 99 (90%) reported the presences of conflicts between hippopotamus and local communities. The major problems of hippopotamus were crop raiding, livestock conflict and human fatality including injury. Conflicts between hippopotamus and livestock were consisting of attacks and competition over grazing grounds (Fig. 18). Educational status of the respondents had no influence on their perception of human - hippopotamus conflicts (X^2= 8.452, df = 4, p =0.076).

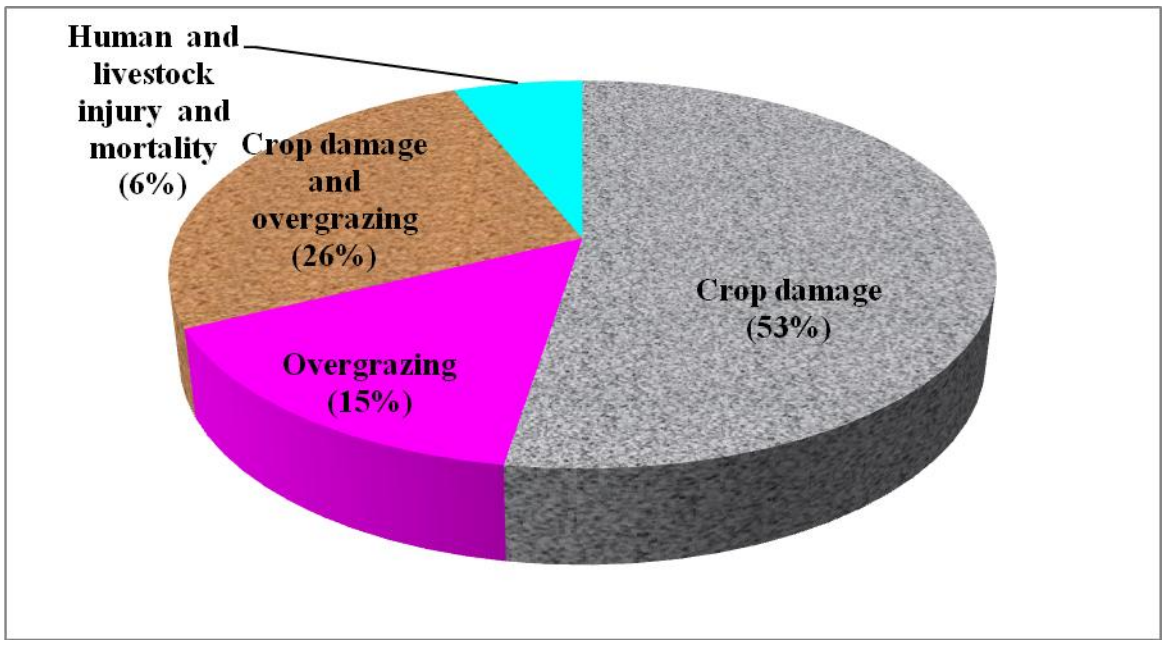

Figure 18: Human - hippopotamus conflicts around the study area

Most of respondents (62.73%) reported maize as the mostly affected crop by hippopotamus, followed by sugar cane (26.36%) (Fig. 19). According to the respondents' information and physical observations the hippopotamus crop damage was not only by feeding but also destroying large area coverage of cropland (Fig. 20).

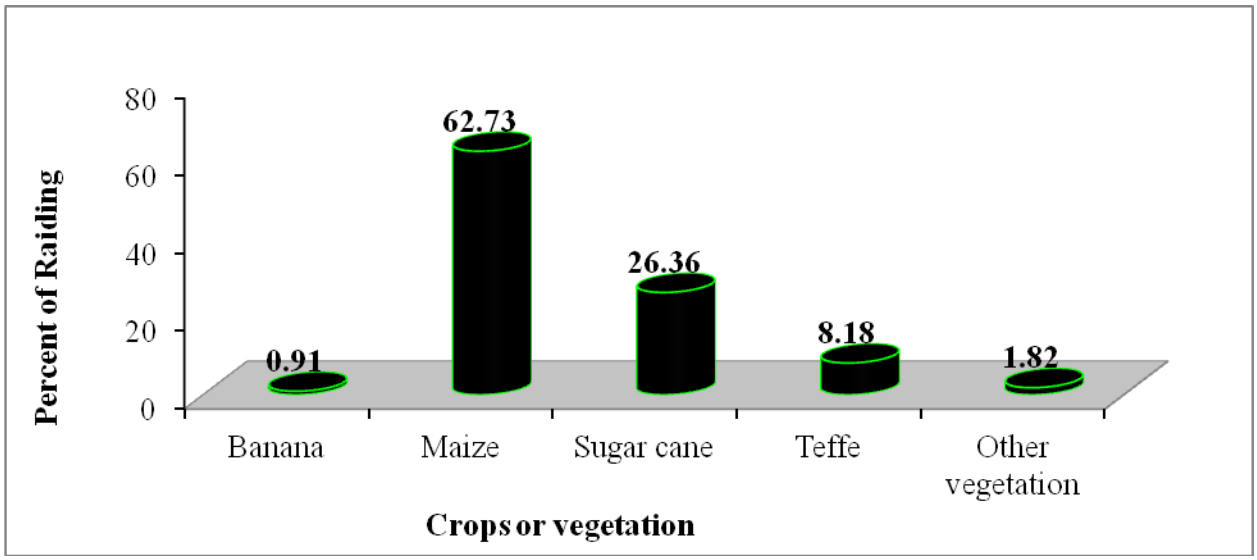

Figure 19: Percentage of crops and other vegetation affected by hippopotamus

Figure 20: Maize and Teffe crops damaged by hippopotamus around Boye wetland (Photo: Sefi Mekonen, 2013)

4.7.6. Crop protection measures adopted by respondents

According to the respondents, local communities adopt different techniques to minimize problems caused by hippopotamus the cropland at night (Fig. 21). Out of these control measures, fire and smoke was the most effective, followed by keeping crops by chasing and scaling the animal with brightly colored objects and throwing stones, shouting whip, and guarded with dogs.

Thorn fences and a narrow and deep trench (at the edge of the cropland, on run way of the animal or entering paths) were the third and fourth respective effective crop protection practice. Digging trench at entering sides of the land covered with grass was used as a trap that the animal cannot come out once they fall into the trench. Fire deposits/charcoal, hook fences and crop/land guarding dwellings were deployed at the edge of crop land and water body in the field (Fig. 22). Chasing of hippopotamuses during the day time resting sites was also another practice to control

the crop from hippopotamus attack. Local communities had no specific method to protect their livestock from hippopotamus injury.

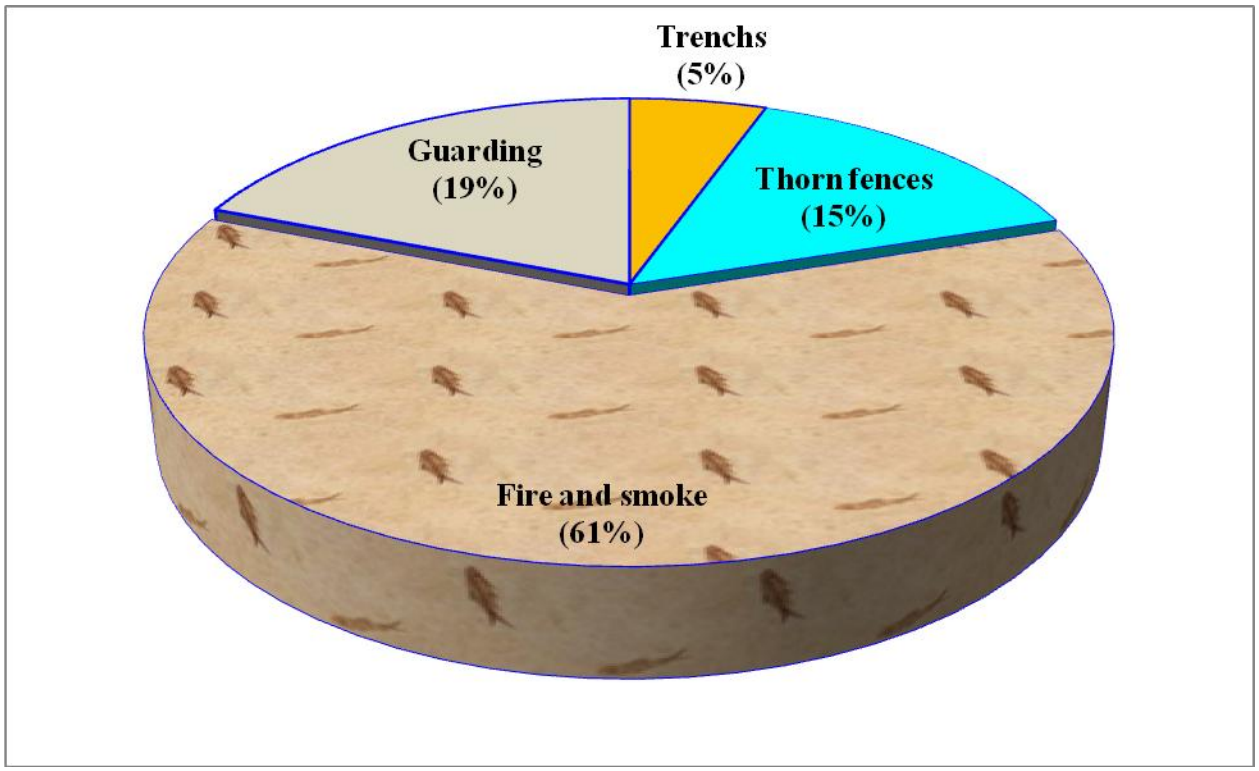

Figure 21: Effectiveness of adopted crop protection methods

Figure 22: Crop protection techniques from hippopotamus damage observed in croplands (A: Thorn fences, B: Guard home, C : Fire) (Photo: Sefi Mekonen, 2013)

5. DISCUSSION

The knowledge of sex ratio and age composition among mammalian populations are crucial for evaluating the status of the population as these variables reflect the structure and the dynamics of the respective populations (Wilson *et al*., 1996). In the present study, the sex ratio of male to female of hippopotamus was unequal (1:1.37). A female-biased sex ratio of this finding shows that the species has healthy, increasing trend in the study area as revealed earlier by Tsi *et al*. (2011) in the Faro National Park, Cameroon. The plausible explanation for the variation in the sex composition may be basically due to the high mortality of males because they are exposed to aggressive interactions with other males and fights between bachelor and territorial males for mating (Zubkowicz , 2005; Blowers, 2008). Reproductive fights may lead to death of weaker males, but stronger males can defend their positions for many years until they have a a strong rival. Females have been observed to live in groups, but males were found solitary in separated sites. As a result, males might be missed in the census period.

In contrary to male to female sex ratio, ratio of young to females (1:1.86) and young to adults (1:3.21) in the present study showed a decreasing status of the hippopotamus. The reason of small young individuals might be young are vulnerable to human and environmental factors and predation than adult. High young mortality might be due to the possibility of adult males killing juvenile males to avoid sharing females in the future as mating of hippopotamus is polygynous (Estes, 1992; Magalhaes and Costa, 2009). Even if an equal sex ratio of animals at birth is assumed, there is an increased mortality of young male ungulates (Ndhlovu and Balakrishnan, 1991).

The first step in studying the relationship between the patterns of distribution and habitat selection of an animal species in a particular area is to identify and measure the characteristics of the area (Mwangi and Western, 1998). In this study, the hippopotamuses associated with the shallow, open, standing and slow running water, which can cover their body and far from the land boundary. This supports the findings of Eltringham (1999), which confirmed that an essential habitat requirement of hippopotamus is open, slow moving, sufficient and shallow water, in which they can submerge totally and surrounded by sufficient grasses to feed. The reason of hippopotamuses was constrained only one resting site in Boye wetland throughout the day is due to lack of other alternative resting sites in the study area. This solitary habitat of the

hippopotamuses is helpful to safeguard them as the animal was take measures to avoid from sun desiccation and human disturbances relative to other sites. Moreover, resting site of hippopotamus was based on the availability of water and distance from human disturbances (Martin, 2005).

Migration is the seasonal movement of animals among different locations and occurs when there is both spatial and temporal variation in the resources (Shaw, 2012). Hippopotamus is a social and gregarious species, which moves in groups of individuals (Tsi *et al*., 2011). In the rainy season of this study, hippopotamus migrated to Gibe River where they stay in the River and graze on pasture lands located along the river banks. This type of migration may allow to some extent to slow down seasonal stress in the wetland. Théophile *et al*. (2012) described that hippopotamuses migrate in rainy season from Biosphere Reserve to the Mouhoun River in the South- Sudanian Zone of Burkina Faso to reduce scarcity of food in the reservoir.

According to field surveys and local community information, explanation of local migration of hippopotamus between Boye and Gibe River is due to seasonal variation of food availability, food preferences and fluctuation of water level and floods. Many large herbivores move out of their habitats during the transition of seasons in response to resource availability or quality (Fryxell and Sinclair, 1988). In the same cause, starting from June water level of Boye wetland increased fed by floods and rain and fashioned standing water due to less flowing out of the water. Therefore, grasses covered or flooded by water might create food scarcity of hippopotamus. This might initiate the movement of hippopotamus to Gibe River.

As Klingel (1991), Nowak (1999) and Fisher *et al*. (2007) described, high accumulations of water and floods affect the movement or walking, standing and breathing of hippopotamuses. Hippopotamuses are rarely found out of contact with the deep bottoms of wetlands, rivers and lakes, and walk underwater rather than swimming. They require enough shallow water and they can stand and kneel on the bottom and be close to the surface of the water and keep their heads above water for breathing when resting (Eltringham, 1999). The dry season immigration of hippopotamus to Boye wetland might be associated with the availability of water and forage in Gibe River reduced and the growth of fresh grasses in the Boye wetland.

Understanding the basic behaviors of hippopotamus will aid in the care and management of populations (Eltringham, 1999). The present study showed, despite hippopotamus spent much of the day time in resting (42.50%), more than half of the day time was spent performing other activities related to moving (34.16%), feeding (19.63%) and mating (3.71%). These results contradict with earlier findings of Timbuka (2012), which described more than half of the day time hippopotamuses rest. This difference might be come from difference in sampling time and technique, nature of the habitat.

The general activity pattern of hippopotamus was characterized by morning and late afternoon peaks with a period of rest in the middle of the day. During the hot time of the day most of them were resting. This is an important adaptation for survival and keeping their skin from sun desiccations (Zubkowicz, 2005). At the mid of the day, the hippopotamus did not try to feed except on cloudy and rainy days. Timbuka (2012) observed that hippopotamuses keep on moving and getting into water frequently during hot days. During the survey, hippopotamus did not completely move out from water. This observation is also supported by Eltringham (1999) and Saikawa *et al*. (2004). Hence, most part of their body was submerged in water and extends the neck to grasses that fluted on the water or grow at the edge parts have to forage.

Mating activities of hippopotamus was recorded only in April in this study. The possible reasons might be mating season came to pass before the beginning of the survey or out of sampled dates. However, hippopotamus mating usually happens within the dry seasons (Magalhaes and Costa, 2009). In mating activity male frequently walks or bathing following the female, smelling each female's posterior end and pushing her to shallows. Then the male climbed to the back of the female and mating begin (Fig. 12). Eltringham (1999) also described similar observation to this study which stated that mating takes place in the water and most of the time the male can be seen rearing up out of the water and the female submerged and the female's nostrils or head to draw breath.

Barking and yawning were observed at any time of the day in both male and female and mostly increased in the afternoon. This pattern is comparable to the findings of Timbuka (2012). Barking or vocalizations were frequently repeated when the animal was fighting and playing with others, searching feeding areas and courtship activities. When one individual raise the vocal

sound, most other individuals also respond. Following yawning, they repeatedly open and close their mouths with low grunt and more head bobbing. The yawning characteristics of male and female hippopotamus were the same.

Water, forage close to the resting site and environmental temperature were the main factors which determined activity patterns of the hippopotamus. Feeding among both male and female hippopotamus was most frequent in April followed by May, slightest in February and March. In February and March the temperature was highest and rain and cloud was least. So, the hippopotamus spent much of the day time in resting and totally submerged in water or in shaded area. On the other hand, in the month of April, the day become cloudy and they become active searching feeding sites and moving. However, decreasing of feeding activity in May might be they have obtained sufficient tender grass at night time and increasing of water and flood regulate walking of the animal to search the food (Fisher *et al.*, 2007).

Generally, availability of forage near the resting sites enabled hippopotamus to feed more during the day time. In addition, this resulted in more walking and feeding and so to spending less time resting. Hippopotamuses are primarily night time feeders (Lewison and Carter, 2004), results of day-time feeding in this study may suggest that forage is limiting in Boye wetland. This activity of feeding might indicate that the animal had less forage during the previous night, possibly due to the distances between resting and foraging grounds or simply taking advantage of forage availability close to where they rest in the day time. It is probable that hippopotamus would utilize a nearby foraging ground if available in order to meet their nutritional requirements (Blowers, 2008). Time used for travel may influence diurnal activity budgets such as animals having to rest instead of feeding. Manteca and Smith (1994) observed varied patterns as animals had to alter their activity budget as resources become scarce.

Barking of female hippopotamus was most frequent in February, and April among males. Least barking was recorded in March both in males and females. Most yawning behavioral events were in April, while minimum yawning was in March and May. The possible reasons of various frequencies of behavioral events of male and female hippopotamus might be related to the presence of disturbances, hunger, playing, aggressive and mating events or behaviours (Eltringham, 1999; Blowers, 2008). The reason of highest yawning and barking records of

hippopotamus in April was due to the presence of mating. As mating of hippopotamus is a prolonged and noisy affair activity and aggressively of dominant male to fight other individuals (Eltringham , 1999).

Assessments of the most and the least eaten plant species are important to make the bulk of the diet of herbivores (Ego *et al.,* 2003). The highest selection ratio for the species suggests that a preference for the food items that the plant species provided while low selection indicates the species is not preferred (Fashing, 2001; Shah, 2003). According to Skinner and Smithers (1990), feeding preferences of hippopotamus depend on local availability of the diets. The number of plant species identified as being consumed (26) by hippopotamus was less compared to the findings of Théophile *et al.* (2012) in the Biosphere Reserve of Burkina Faso (34 plant species). But, the difference in the number of plant species reported as consumed by hippopotamus in the present study area and the former might be due to the duration of study periods. Théophile and his associates collected the data for three consecutive years, while the present study was short period.

Eriochloa fatmensis, Typha latifolia, Echinocloa pyramidalis, Cynodon dactylon, Echinochloa crus-pavonis, Cynodon plectostachyus, Leptochloa rupestris and *Cyperus rigidifolius* were the most palatable species. These species are mainly from Poaceae family. This finding is agreement with previous studies by Noirard *et al*. (2004) and Théophile *et al.* (2012). Lewison and Carter (2003) and Chansa *et al.* (2011), who reported that hippopotamus consume grass species such as *Echinochloa pyramidalis, Cynodon dactylon* and *Commelina benghalensis*. These grass species contributed for the third, fourth and eleventh ranked in the diet percentage, respectively in the present study.

These major consumed plant species were also frequently observed in direct observations of the animal feeding around the day time resting site in the morning and let afternoon hours. But *Echinochloa crus-pavonis, Cynodon plectostachyus* and *Cynodon dactylon* were not recorded in direct observations. Hippopotamuses eat aquatic plants, with observations being made of them nibble on floating plants as well as various types of reeds (Eltringham, 1999).

In addition to the plant species found in grazing are, Maize (*Zea mays*), Sugar cane (*Sacchurum officinarum*), Banana (*Musa paradisica*) and Teff (*Eragristis teff*) were crops heavily consumed by the hippopotamus when located near the wetland. Admassu (2007) and Théophile *et al.* (2012) also reported maize, Sugar cane, and other vegetable were eaten by hippopotamus and cause human conflicts.

Hippopotamuses reached their pastures along well-worn tracks. Their regular movements from water pool to pastures and vice - versa have created trails and water channel geomorphologies were modified (Post, 2000). The mean value of circumferences and distances of footprints were positively correlated (r = 0.795). This means the sample site where maximum footprint circumference measured also had long distance between consecutive footprints and the opposite also true. This positive correlation between footprint circumference and distance might indicate the size of the leg or the animal. Maximum footprint circumference and distance measured site might be the run way or track of the largest individual. The minimum average value also might estimate the smallest hippopotamus. The minimum, mean and maximum footprint measurement value might be indicate young's, sub - adult's and adult's hippopotamus, respectively as the age of elephants (Western e*t al*., 1983). However, hippopotamus's footprint distance value (70.67cm to 103.67cm) in this study is higher than elephant's footprint distance (21.80cm to 44.20cm) (Western e*t al*., 1983).

Field observation and respondent responses show that, major threats of the hippopotamus around the study area were habitat distractions by expansion of agriculture and settlements, flood sedimentation from Jimma town, competition with livestock and killing and chasing of the hippopotamuses by local people. UNEP-WCMC (2010) also remarked similar threats of hippopotamus in Ethiopia around the Dabus, Omo and Awash Rivers, the Boyo wetland and the Tana, Awasa, Zeway, Abaya and Chamo Lakes which are inhabited by hippopotamuses. Findings of the present study are also in agreement with Kanga *et al*. (2011a, b) who have studied in Mara River, Kenya, and Kujirakwinja (2010) in Virunga National Park, Democratic Republic of Congo with potentially adverse consequences.

The population of hippopotamus has been declining in response to human disturbances and threats in Africa (Lewison, 2007). The local people around the study area had also responded negatively by chasing, noise making and killing hippopotamus when seen the animal. These disturbances may regulate the animal freely moving, resting and feeding in the area. Human activities influence ecosystem structure and function, in particular the spatial and temporal distribution of wild herbivores (Redfern *et al*., 2003; Ogutu *et al*., 2010). This is especially true in Boye wetland, where water availability becomes progressively limited and water sources become points of contacts and conflicts and competition between hippopotamus and livestock.

Most of respondents (47.3%) had negative attitude towards hippopotamus, while 37.3% had positive attitude. Frequent crop damage problems, conflict with grass collectors and livestock competition tendency of hippopotamus were the main reasons for the local community to oppose the presence of hippopotamus. However, reasons for the positive perceptions of respondents about hippopotamus like recreational, tourism and educational values lead to the local community had positive attitude. Based on such values and positive attitude of local community, 34.50% of the respondents want to involve in management or conservation of hippopotamus, but 65.5% of the respondents had no interest in conservation of the animal due to the problems faced to the community.

According to UNEP-WCMC (2010), the major threat of hippopotamus in Ethiopia is poaching for ivory, hide, bush meat and illegal local trade of hippopotamus tusk teeth. However, all respondents (100%) were acknowledged that there is no hippopotamus poaching for ivory, meat and trade around the present study area. This is because, culturally, the people in the area do not have a trend to eat meat of hippopotamus, make ivory and tusk for market and absence of local markets for such items. But, they shoot hippopotamus for its hide and to guard and protect crops around the wetland. Similar threats were also reported by Admassu (2007) around Awash River.

The pattern of human - hippopotamus conflict is consistent with the observation that over 94% of the entire conflict rate was related to agriculture (crop damage and over grassing of grassland) and is similar to that reported by Mkanda and Kumchedwa (1997) and Kanga *et al*. (2011a). The probable proximate causes of these patterns of human-hippopotamus conflict are linked to increasing human population associated with increase agricultural and settlement area. In

addition, competition with livestock may be forcing hippopotamus to forage extra from their daily living space and increasing their probability of contacts with humans (Cerling *et al*., 2008).

Crop raid by hippopotamus unpredictable and can cause more damage per raid (Hoare, 1992; Eltringham, 1993). Crop damage by hippopotamus was by feeding, by trampling and destroying certain areas of the field. Due to their large body size and very wide-ranging foot, the hippopotamus was able to damage much crops on the land. These negative effects of hippopotamus to local community cause the mortality and chasing of the animal by shooting, disturbing and destroying the wetland.

Although, hippopotamuses are identified among dangerous animals and said to account for more human deaths than any other African mammals (Nowak, 1991; Post 2000), the severity of cause of death and injury of human and livestock by hippopotamus in this study was less (6%). The reason of death and injury of human and livestock by hippopotamus listed as a slightest source of conflict around the study area may be the wetland regulates the probability of humans and livestock going to the feeding and resting sites of hippopotamuses at night.

The different approaches to reduce conflict between local communities and wild herbivores across Africa are documented in different studies (Osborn, 1998; Hoare, 1992). Local residents in the study area used different techniques to minimize agricultural crop damage by hippopotamus like fire, guarding crop by chasing the animal with brightly colored objects, stones and shouting whip, thorn fences and digging narrow and trench. Similarly, farmers live in and around Lake Victoria used fencing materials like cedar poles and barbed wire and digging of trenches to minimize crop damage by hippopotamus (Post, 2000).

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

According to the current available population data, habitat area and respondent's information, the status of hippopotamus is critical and it is likely to continue to decline unless effective conservation strategies are planned and implemented. The distribution, local migration and habitat selection of hippopotamus determined by water and pasture conditions or the combinations of both and human disturbances. Hippopotamus strongly interlinked with open, sufficient and shallow water and surrounded by grass habitat in Boye wetland regardless of in the wetland and are River habitat specialists.

Hippopotamus spend much of their activity time budget for resting and moving than feeding and mating in both male and female, while barking is more than yawning in female and least in male. Female hippopotamuses were more active than males both in activity and event patterns except mating. Activity patterns of hippopotamus show peaks in morning and late afternoon with a period of rest in the middle of the day. Components of activity and event patterns varied between months.

The present study has shown that there is a human-hippopotamus conflict around the Boye wetland. The extent of crop damage, over grassing and livestock competition of hippopotamus leads to negative attitude of local people towards hippopotamus. Expansion of agriculture, increasing of settlements and livestock in the wetland of the Boye will progressively increase both the intensity and extent of human impact on hippopotamus, thereby shifting the wetland to dry land. Therefore, due attention should be given to alleviate the problem.

6.2. Recommendations

Based upon the present study, the following suggestions are recommended to mitigate threats and human - hippopotamus conflict in the study area.

- The Jimma town council should take an action to discourage or prohibit the expansion of human settlements.
- Local people should participate in the process of conservation and resolving the existing conflicts in order to foster positive outlook towards hippopotamus.
- The problem of agriculture and other human activities that degrade the natural habitat should be strictly reduced.
- Awareness creation programmes should be prepared for local people to ensure the sustainability of the wetlands for their economic and societal benefits.
- Boye wetland and its associated area should be declared as a sanctuary or protected area for hippopotamuses.

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APPENDIXES

Appendix 1. Interview questions related to local migration of hippopotamus

1/ How many hippopotamuses do you have seen in this year in Gibe? _____

2/ Are hippopotamus lived in Gibe throughout the year? A. Yes B. No

3/ From where and when they come and migrate again? (Specify area and months)_____

4/ Is that Boye's and Gibe's hippopotamuses are the same group?

5/ Where is the migratory corridor?

6/ What do you think the main causes for this local migration? -

_____

7/ When you compare the hippopotamus population size of the present and the past

A. increasing B. decreasing

8/ What do you think the main causes for this change?

_____

Appendix 2. Questionnaires related to threats, human-hippopotamus conflicts and attitude of local community to hippopotamus in Boye wetland

A. Introductory questions

Respondent number_____

1. Age _____ Sex_____ family size _____

2. Educational status

a. illiterate

b. Read and write only

c. Elementary

d. High school

e. Beyond secondary education

3. Time living in the area _____years.

B. Household Economy and Resource Use

4. Does your livestock graze in the Boye?

A. Yes _____ B. No _____

If "yes" how many

1. Sheep? _____

2. Goats? _____

3. Cattle? _____

4. Horses? _____

5. Donkeys? _____

5. How long do you use for grazing in Boye? _____

6. Do you have farm land around the study area?

A. Yes ---------- B. No ----------

If "yes" what is the size of your farming land? _____

What type of crop did you grow?

a. _____ c. _____

b. _____ d. _____

D. Attitude and perception of community on hippopotamus

7. What do you feel on the number of hippopotamus in Boye?

Increasing □ Decreasing □ Stable □ No idea □

8. Do you think your activities have factor on the hippopotamus numbers and its habitat?

Yes □ No □

How/Why not?_____ 9. What is the value of the Hippopotamus in the study area?

_____

10. Do you want to involve yourself in managing/conserving the hippopotamus? Yes □ No □

If No, why? _____

11. What is your opinion on the size of the wetland for the survival of hippopotamus?

Too big □ Too small □ Right size □

C. Conflict and Damage

12.Is there any resources that you have been prevented from Boye due to the presence of hippopotamus?
Yes □ No □

If yes, mention_____

13. Are there conflicts between hippopotamus and people? Yes □ No □

14. What kind of problems do you (household) face because of hippopotamus?

□ Crop damage

□ Overgrazing the grassland

□ kill humans or animals

□ Others specify_____

15. Which crop is most affected by Hippopotamus?_____

17. How is the extent of problems by the hippopotamus?

Very little □ Much □ Very much □

18. What is the tendency of the problems from time to time?

Increasing □ Decreasing □ Stable □

20. Which season is the problem more severe? _____Specify the months_____

21. Describe the different techniques you use to control (minimize) the problems caused by hippopotamus

i _____

ii _____

iii _____

22. Which of these techniques are most effective? _____

23. Is there any hippopotamus hunter in your area? Yes □ No □

Appendix 3. Data collection sheet for hippopotamus counting

Date	Time	Male	Female	Young	Total

Appendix 4. Data sheet for behavioural records

Date_____ Time interval: 30 minute

Sex of focal sampled hippopotamus_____

Start Time_____ End Time_____

Time	Activities				Events	
	Feeding	Moving	Resting	Mating	Barking	Yawning

Appendix 5. Data sheet for observation of hippopotamus threats and disturbance

Observation	Date								
No. of Hippo observed									
Cattle									
Horse									
Donkey									
Sheep									

Goat									
Human activities									
collecting grass									
Farming									
Response of humans to Hippo									
Chasing									
Noise making									
Try to kill									