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**Ecological Studies of Marabou Stork (*Leptoptilos crumeniferus*)
around Hawassa Lake, Southern Ethiopia.**

By

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Hawassa Lake, Southern Ethiopia.**

A Thesis Submitted to the Department of Zoological Sciences in Partial Fulfillment of
the Requirements for the Degree of Master of Science in Ecological and Systematic
Zoology

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Table of Contents

Contents	Page
Dedication.....	i
Acknowledgements.....	ii
Lists of Tables	iii
Lists of Figures	iv
Lists of Plates	v
List of Appendices.....	vi
ABSTRACT	vii
1. INTRODUCTION.....	1
1.1. Background.....	1
1.2. Statement of the Problem.....	12
1.3. Significance of the Study.....	13
1.4. Objectives.....	14
1.4.1. General objective.....	14
1.4.2. Specific objectives	14
2. MATERIALS AND METHODS.....	15
2.1. Description of the Study Area.....	15
2.2 Climate of the Study Area.....	18
2.3. Materials	20
2.3. Methods	20
2.3.1 Preliminary Survey	20
2.3.2 Basic counts	21
2.3.3 Feeding Ecology.....	22

2.3.3 Nest monitoring	22
2.4 Data Analysis.....	23
3. RESULTS	24
3.1 Abundance and Distribution.....	24
3.2 Feeding Behaviour.....	27
3.3 Habitat Association.....	30
3.4 Reproduction	31
3.4.1 Breeding.....,	31
3.4.2 Nest.....	32
3.3.3 Egg.....	34
3.4.4 Hatching.....	35
4. DISCUSSION.....	38
5. CONCIUSION AND RECOMMENDATIONS.....	41
5.1 CONCLUSION.....	41
5.2 RECOMMENDATIONS.....	42
6. REFERENCES	43
7. APPENDIX.....	48

Dedication

This work is dedicated to my lovely boy Nethaneel Misgana and my husband Misgana Fanta for their affectionate love and persistent pray that I become successful in pursuit of my academic ambitions.

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List of Tables	page
Table 1. Number of Marabou stork eating during wet and dry seasons.....	27
Table 2. Nest Morphometry.....	33
Table 3. Marabou stork eggs Morphometry.....	34

List of Figures

page

Figure 1. Undertail covert of Marabou stork compared to “Marabou” feather of white domestic turkey.....	4
Figure 2. Map of Hawassa Town and Lake Hawassa study area.....	17
Figure 3. Monthly temperature of Hawassa(2017)	18
Figure 4. Monthly Rain fall of Hawassa (2017).....	19
Figure 5. Distribution of Marabou stork during both seasons.....	24
Figure 6. Marabou stork population count for all the survey sites during dry season.....	25
Figure 7. Marabou stork population count for all the survey sites during wet season.....	25
Figure 8. Juvenile and adult population of Marabou stork during both seasons.....	26
Figure 9. Food items of Marabou stork all study sites.....	28

List of Plates	page
Plate 1. Butchering fishermen in the fish market of Lake Hawassa.....	8
Plate 2. Counting the number of Marabou stork at fish market.....	21
Plate 3a. Marabou feed on scrap at Tikur Wuha during the wet season.....	28
Plate 3b. Marabou feeding on carrion walking on the lake shore at fish market during the wet season.....	29
Plate 3c. Marabou feeding on insect walking on the ground at Fikir Hayik during the wet Season.....	29
Plate 4a. Marabou roosting on a house building.....	30
Plate 4b. Marabou walking on road Fikir Hayik.....	30
Plate 4c. Marabou roosting on <i>Acacia</i> tree around the fish market during the night and wet season (left) and day time during the dry season (right).....	30
Plate 4d. Marabou at the lake shore.....	31
Plate 4e. Marabou roosting on ground at Tikur Wuha.	31
Plate 5a. Marabou building nest using branches of leaves on <i>Acacia</i> tree.....	32
Plate 5b. Nest of Marabou near to the main road of Hawassa Lake.....	33
Plate 6. Clutch size of Marabou stork.....	34
Plate 7 a. Newly hatched Marabou stork chicks.	35
Plate 7 b. Chicks of fifteen days old Marabou stork.....	36
Plate 7c. Thirty days old (Left) and Forty five days (Right) Marabou stork chicks.....	36
Plate 7d. Fully fledged Marabou stork.....	37
Plate 7e. Fully developed marabou stork.	37

List of Appendices	page
Data Sheet 1 Distribution and Abundances.....	48
Data Sheet 2 Breeding Behaviors.....	49
Data Sheet 3. Nesting material used, clutch size and condition.....	50

Abstract

Ecological Studies of Marabou Stork (*Leptoptilos crumeniferus*) around Hawassa Lake, Southern Ethiopia.

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A study was carried out around Lake Hawassa, covering both wet and dry seasons in 2017/18, to investigate the population structure, habitat association, feeding ecology and reproductive patterns of the Marabou stork (*leptoptilos crumeniferus*). Sample sites were designed based on the vegetation type and area cover. Point count and nest monitoring method were used on the three selected sites. Direct observation techniques were also used to collect necessary information. A total of 289 and 366 Marabou storks were counted during the dry and wet seasons, respectively. Birds counted during the dry and wet season, were significantly different ($p < 0.05$). Lake shore was highly preferred for feeding. They were observed to feed on food items such as fish scraps (35%), carrion (27%), insects (13%), worm (12%) and frog (11%), with variations from season to season. Their breeding nests were mostly in the town and on the top of *Acacia tortilis* and *Acacia nilotica* trees. On average, the female laid 3 eggs and both parents share in guarding and incubating eggs for 29-31 days. Marabou take long period of 124 days from hatching to fledging, with first flights out of nest during 90-110 days. The chicks show variation in physical status at different days. Habitat degradation in connection with recreation area and extreme exploitation of fishing activities are the main threats to the survival of Marabou storks and other wetland birds of the present study area.

Key words/phrases: *Acacia*, Hawassa, Marabou stork, Water birds.

1. INTRODUCTION

1.1 Background

There are approximately 10,000 different species of birds worldwide. Many of these are endangered or critically endangered (Birds in the World.htm). A total of 190 species, which is 2% of the avian species are considered critically endangered facing extremely high risk of extinction in the immediate future due to human driven threats, for which immediate actions are needed (Bateson and Martin, 2007). An estimated 2,500 species are endemic or migrate to Africa (Birds in Africa.htm). Among the various African countries, Ethiopia is unique for its geographic conditions and is blessed with plenty of water resources, large green fields, and diverse flora and fauna. It possesses considerable biodiversity and natural resources, as well as many endemic bird species. According to Shimelis Aynalem and Afework Bekele (2008), out of the 926 bird species listed for the country, 21 are endemic and 19 are globally threatened species. Ethiopia is one of the few countries in the world that possesses a unique and characteristic fauna with a high level of endemism (WCMC, 1992). The Ethiopian Rift Valley also known as the Afro-Arabian rift is one of the greatest East African Rift Valleys that extends from Jordan in the Middle East to Mozambique and Kenya in the south. It divides Ethiopian highlands into north and south halves. The volcano-tectonic basin is created as a result of faulting, and later modulated into lakes. There are several fresh water lakes found embedded in this basin. Among them the most prominent are Ziway, Abijata, Abaya and Hawassa Lakes (Pattnaik, 2014).

Among the birds that are widely distributed in Africa are storks. Different types of storks live worldwide. Storks have either straight or curved bills, some species resemble vultures with bald heads and a taste for carrion (Stevenson and Fanshawe, 2011). There are 19 species of storks inhabiting many parts of the globe where the climate is warm. Storks belong to the family Ciconiidae and order Ciconiiformes closely related to flamingos, ibises and herons. Storks have long legs and webbed toes ideal for wading in shallow water to catch fish. Storks are capable of hissing, grunting and clattering their beaks. Storks tend to use soaring, gliding flight, which conserves energy. Soaring requires thermal air currents (Kahl and Peacock, 1999). Many species of Storks migrate.

Most storks consume frogs, fish, insects, earthworms, small birds and small mammals. Storks have a nearly cosmopolitan distribution, being absent from the poles, most of North America and large parts of Australia (Nevoux *et al.*, 2008). The centers of stork diversity are in tropical Asia and sub-Saharan Africa, with eight and six breeding species respectively. Storks build huge nests on trees where both parents care for the young. Nests may be used for many years (Cherokee, 2017).

Storks are typically viewed as wetland species and some storks are restricted to aquatic habitats (Morgan, 2004). Marabou stork (*Leptoptilos crumeniferus*), Saddle-billed stork (*Ephippiorhynchus senegalensis*), Yellow-billed stork (*Mycteria ibis*), African open bill (*Anastomus lamelligerus*), Woolly-

necked stork (*Ciconia episcopus*) , Abdim's or White-bellied stork (*Ciconia abdimii*), White stork (*Ciconia ciconia*), Black storks (*Ciconia nigra*) , Wood stork (*Mycteria americana*) and Shoe bill (*Balaeniceps rex*) are the different species of storks (Riley, 2012).

Storks range from being solitary breeders through loose breeding associations to fully colonial. The jabiru, Saddle-billed storks and several species of *Ciconia* are entirely solitary during breeding. In contrast, the Wood storks, Abdim's stork, openbills and Marabou storks breed in colonies which can range from a couple of pairs to thousands (Thomas and Maruska, 1996). Many of these species breed in colonies and share other water birds, which can include other species of storks, herons, egrets, pelicans, cormorants and ibises. White storks, Oriental storks and Maguari storks are loosely colonial, and may breed in nests that are within the visual range of other same species, but have little to do with one another. They also may nest solitarily, and the reasons why they choose to nest together or apart are not understood (Dean, 1994).

The Marabou stork (*Leptoptilos crumeniferus*) is resident in tropical Africa and is common to abundant over much of its range (Hancock *et al.*, 1992). Marabou's fluffy undertail feathers known as "marabou dawn" were used extensively as hat ornaments. Indeed, the genus name *Leptoptilos* is derived from the Greek words (for fine) (*leptos*) and (feather) (*ptilos*). These feathers were popular in Europe for the Millinery trade and for decorative feather work, especially in the 19th and early 20th centuries (Trail, 2005).

The fine undertail coverts of marabou stork can be easily distinguished from the “Marabou” feathers of Turkey or chicken by a trained observer. The most obvious macroscopic characters are that genuine Marabou stork undertail coverts have long, fine, rather tangled barbs with no apparent gap (“window”) along the shaft (Fig. 1). In contrast, Turkey “Marabou” feathers have shorter, denser barbs with an almost woolly texture, and an obvious window along the shaft (Trail, 2005).

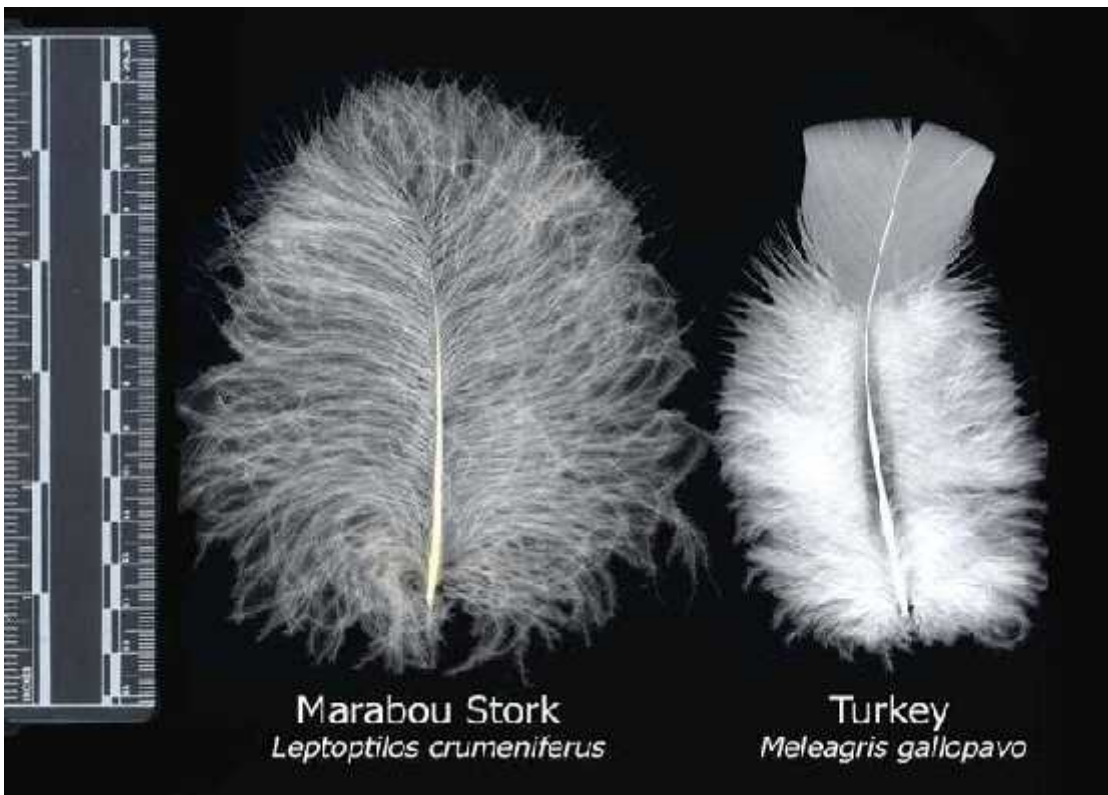


Figure 1. Undertail covert of Marabou stork compared to “Marabou” feather of white domestic Turkey (Source, National Bird and Wildlife Forensics Laboratory, 2005).

The Marabou Stork, also known as “undertaker bird” primarily due to their appearance. When one looks at these birds from behind, they look almost like

they are wearing dark cloaks due to the black feathers on the back and wing, and white fluff around the neck. The thin white "hair" on their mostly bald heads makes them look a bit like little old men. As with vultures, the baldness is an adaptation to help keep their heads clean from rotten food and other debris. It stands on long, grey legs at about 1.5 m tall with a 2.6 m wing span (Winterbottom, 1971). It is very large and heavy that the leg and toe bones are hollow to reduce weight during flight.

Marabous have a long tan beak, long legs, a white chest of feathers and wings covered with dark grey or black feathers. The soft, white tail feathers are known as marabou (fluffy decorative feather material) (Winterbottom, 1971). Adults can weigh up to 6 kg and can have a wing span as large as 4 m (Winterbottom, 1971). It is the only species within its genus with a dark iris. The sepia-brown to grayish-brown iris gives the eye an overall brown colour.

Marabou storks have a visible red throat air sac on their neck that can inflate and deflate. This is particularly conspicuous during the breeding season. It connects directly to the left nostril and acts as a resonator allowing the bird to produce a guttural croaking. While usually silent, marabou stork will also emit sound caused by beak clacking while it feels threatened. This pouch is used in courtship rituals as well as for thermoregulation and it is also a sign of dominance and territoriality. Another sac can be found on the "hind neck" or behind the head and is hidden by feathers (Harrison and Greensmith, 1993). A collar of fluffy white feathers encircles the base of the neck. The skin of the cheek and crown is reddish and is covered with numerous black spots (Monadjem *et al.*, 2008).

Marabou storks are scavengers like Vultures. They have an important ecological role to play feeding in groups on a variety of food items (carrion, fish, bugs, frogs, snakes, mice and rats). Its diet consists predominantly of carrion and scraps of fish discarded by humans as well as live fish, termites, locusts, frogs, lizards, snakes, rats, mice and birds (Bwangamoi *et al.*, 2003). Even though they eat garbage, they like to keep it clean. They will sometimes dip their food in water to rinse off dirt before eating. Their habitat ranges from savannas to river banks or lake shores. However, their eating habits have led them into urban areas where they can access garbage and waste from abattoirs and fishing villages and other (Clements *et al.*, 2014). Like all birds, Marabou stork's choice of habitat is dependent upon the availability of food. Most marabou storks live in open country in arid or semiarid areas, but there is always a body of water within their flying ranges. Marabous hunt for fish and aquatic insects in large lakes, rivers and even small ponds (Brown *et al.*, 1982). They have a voracious appetite and occur scavenging near vulture attacks. Refuse, slaughter houses and garbage dumps attract Marabou storks. The Marabou feed on fish head or other offal helping to keep cities and villages clean (Christensen, 2014).

Long legs and partly webbed feet are used for wading in the water. Since the leg and feet are black, they absorb heat overheating the body. To cool the body, they defecate on the legs and feet turning them gray (Burnie, 2001). Like Marabou Turkeys, Vultures have strong antiseptic properties in their whitewash however, the reasons for carrying out this act are different. This helps to assist in regulating body temperature, and also gives the false appearance that the birds have lovely white legs. This 'white washing' is called urohydrosis and changes

the colour of their normally black legs to gray (Alden, *et al.*, 2012). Marabou long legs and partly webbed feet are well suited for wading in shallow water across its tropical African range (Henry, 1903).

Marabou storks occur throughout Africa. Mostly sub-Saharan Africa, largely excluding the lowland forest of West Africa. In southern Africa, it is fairly common to locally abundant in central and southern Mozambique, Zimbabwe, north-eastern South Africa, northern Botswana and central and northern Namibia. It generally prefers open semi-arid habitats and wetlands, such as pans, dams and rivers (Dinsmore, 1997). This species is sedentary or locally nomadic. Populations in the north and south generally move towards the equator after breeding and movements in relation to water availability or prey abundance (Hancock *et al.*, 1992). In the tropics, the species begins to breed during the dry season, but in the equatorial zone, the timing of breeding is more variable. It breeds in colonies numbering 20-60 up to several thousand pairs and often nests with other species. The nest is constructed of sticks and is positioned 10-30 m above the ground on trees, cliffs or buildings in towns and villages (Seibt and Wickler, 1998). The species breeds colonially in single- or mixed-species groups, usually in close proximity (less than 50-60 km) to a reliable food source (Barnes, 1998). *Euphorbia*, *acacia* and *baobab* trees are the favorite communal roosting and nesting sites of the stork (Newman, 2002). During non-breeding season, the species often remains gregarious, feeding in groups and gathering at night in communal roosts of up to 1,000 individuals (Hancock *et al.*, 1992). It may also associate with herds of large mammals in order to prey insects disturbed by their movements.

It inhabits open dry savannas, grasslands, swamps, riverbanks, lake shores and receding pools where fish are concentrated, typically foraging in and around fishing villages where fishermen remove fish scraps and dump waste (Plate1.) (Hancock *et al.*, 1992).

Hawassa and Ethiopia's other booming towns such as Arba Minch and Ziway are all home of colonies of Marabou storks, which roost on the crowns of the flat-topped Acacias that line the cobbled or tarred streets (Tortosa *et al.*, 2002). Males and females are alike with the female being slightly smaller. Sexual dimorphism and individual size variation are important in the living large Ciconiidae, tribe Leptoptilini. Male Marabou storks are larger in size than females (Louchart *et al.*, 2005).



Plate 1. Butchering fishermen in the fish market of Lake Hawassa. (Photo by: Misgana F. 2017).

Marabou storks breed in colonies, starting during the dry season because at this time the water levels are low, making it easier to catch frogs and fish to feed the young. The finished nest of a pair of Marabou storks measures three feet in diameter and a foot thick. Their young reach sexual maturity at 4 years of age but they breed at 6-7 years of age. Lifespan is 41 years in captivity and 25 years in the wild (Fisher, 2014). First, a 6-7 year old male selects a site, 9-13 m high on a tree and waits for a courting female. The female persistently performs submissive displays because the male rebuffs males and females approaching his territory. Once a pair is established, the male collects coarse sticks for their platform nest, which is built almost entirely by the female. She lays 2-3 eggs and both parents share incubation duties. After about 30 days, the eggs hatch at 1-3 day intervals. The hatchlings are pink and wrinkly. Both parents feed fish to the young by regurgitating food onto the floor of the nest (Burton and Burton, 2002). Marabous take an extremely long period of time about 135 days from hatching to fledging. The first flight out of the nest is during 95-115 days (Tarboton, 2001).

Most breeding is confined during the dry season, for a number of possible reasons:(1) carrion is more readily available during drought when animals are concentrated in a few areas of remaining surface water, (2) aquatic vertebrates become concentrated and easier to catch in many habitats when water is receding, (3) some prey is caught by the grass fire, which are common only during the dry weather (David and Gosselin, 2011).

Marabou storks molt their feathers sequentially, continuously, and slowly,

except when gaining their first set of feathers, which takes 3 months. These feathers are retained for a further 8 months after fledging. The duration of molt varies with the type of feather, which is a year for primaries and 12–15 months for secondaries (Pomeroy, 2001). They often stand and sun bath, with their broad wings held open. Ultra violet rays also kill potentially harmful bacteria on their feathers and sunlight synthesizes vitamin D and helps to maintain the shape of the feather (Alden *et al.*, 2012).

Marabous also gather in large numbers at communal roosts containing up to a thousand other storks. Marabous are normally silent, as their voice box lacks muscles, but they emit grunts and squeals while roosting. Perching high on the trees, it helps takeoff site for their early morning flights to feeding grounds (Casey and Gaunt, 2015). Marabou storks use one of the most energy-efficient ways of flying: thermal soaring. Thermals are accumulations of the early morning heat that rise, often becoming visible as tufts of cloud, which the bird easily identifies (Burton and Burton, 2002). Storks use rising air to ascend, then glide to the base of the next thermal. They often soar thousands of feet high. However, they are easily distinguished from other birds in flight. Their long legs are held slightly away from the body and trail behind the bird (Newman, 2002).

Like many birds, Marabou storks also pant when the days become hot, to lower their body temperature. They are lazy birds and spend much of their time standing motionless (Clutton-Brock *et al.*, 1995). Like other storks, they fly with their especially long legs trailing behind, but unlike others they keep their neck tucked well in and bent into a flattened S shape. This allows the weight of the heavy beak to be taken on the shoulders (Liebenberg, 1990).

Marabou storks are common to abundant elsewhere in their range and benefit from their association with humans due to proliferation of rubbish dumps. However, as sanitation improves, the population will probably decline (Kahl, 2008).

Lake Hawassa is among one of the biggest bird sanctuaries in the rift and home for several hundred species of water birds, including local and Palaearctic migrants with large population of Marabou storks (Pattnaik, 2014). This species has an extremely large range, and hence does not approach the thresholds for Vulnerable under the range size criterion. So the population trend appears to be increasing and very large in size. For these reasons, the species is evaluated as Least Concern in the IUCN Red List (<http://www.iucnredlist.org>).

The ecology of Marabou stork in Ethiopia has not been studied in detail. They occur in some wetland area of the country. The current population structure, habitat association, breeding, feeding ecology and conservation problems of Marabou stork in relation to human impact are poorly known. The present study attempts to gather information on the seasonal distribution and habitat association of Marabou storks in the study area. The study is also an attempt to gather information on the population structure, habitat association, feeding behaviour and the egg size, clutch number and nest building patterns of this species around Lake Hawassa, Ethiopia.

1.2 Statement of the problem

In southern Ethiopia such as Hawassa Lake, there were a lot of studies carried out on water bird diversity, distribution, abundance, and feeding and reproductive behaviour. Ethiopia's Rift Valley lakes such as Lake Ziway and Hawassa are famous for the Marabous that hang around fish markets.

However, studies on population ecology, habitat preference, feeding and reproductive habits, nest building and clutch size of Marabou stork are still poorly known at Hawassa Lake. This initiated the researcher to conduct research in order to investigate and identify its ecology. Therefore, this study will be designed to identify the distribution, habitat preference, and association, feeding and reproductive behaviour, nest building and clutch size of Marabou stork to gain information for further conservation.

1.3 Significance of the study

This study is important to identify the seasonal (summer and winter) distribution, abundance and habitat association of Marabou stork around Lake Hawassa and to understand the seasonal feeding behaviour of Marabou Stork. It also indentifies reproduction pattern in relation to season and habitat preference. Analysis of this information in turn reveals to identify the nest building material, type and place. The findings of this study will also be a relevant input for any interested individual who would like to conduct further study and conserve their system.

1.4 Objective

1.4.1 General objective

- The general objective of the study was to assess the distribution, habitat association, feeding behaviour and patterns of reproduction (nest building and clutch size) of Marabou stork around Lake Hawassa.

1.4.2 Specific objectives

The study was aimed to achieve the following specific objectives:

1. To describe seasonal distribution and abundance of Marabou storks.
2. To assess habitat association of Marabou storks.
3. To study the feeding behaviour of Marabou storks.
4. To determine and measure egg size, clutch number and nest building patterns.

2. MATERIALS AND METHODS

2.1 Description of the study area

The present study was carried out along the shores of Hawassa Lake, near Hawassa town, southwest Ethiopia located 275 km south of Addis Ababa. Hawassa town serves as the capital of the Southern Nations, Nationalities, and Peoples' Region. It lies on longitude and latitude of $6^{\circ} 57' \text{N}$ - $7^{\circ} 9' \text{N}$ and $38^{\circ} 24' \text{E}$ - $38^{\circ} 30' \text{E}$ respectively, at an elevation of 1700 m above sea level.

Hawassa Lake is the most prominent freshwater lake found in the central Ethiopian Rift Valley located at the highest topographic position. Five independent small and big rivers drain into the lake extending the catchment. Run off from the eastern wall of the caldera feeds another small lake called lake Cheleleka. The Overflow drains into Lake Hawassa through the Tikur Wuha River, which is the only major affluent river in the area (Chernetsov *et al.*, 2004) (Fig. 2).

Lake Hawassa covers an area of about 12,900 ha. The surface area of this ranges between 8,500 and 9,000 ha and the maximum depth is c.18–22 m. The shoreline varies between 50 and 65 km in length. Hawassa Lake is the smallest of the Rift Valley lakes, but is highly productive. It has a rich phytoplankton (over 100

species have been identified) and zooplankton diversity that support large populations of six fish species. The most important commercial species is *Oreochromis niloticus*, but there are also good populations of catfish and *Barbus* (Fekade Daniel, 2012).

Lake Hawassa is the most studied of the Rift Valley Lakes. Set in a volcanic crater, it has an abundance of plankton and fish that supports the Hawassa city (Kahl, 1986).

The lake is among one of the biggest bird sanctuaries in the rift and homeland for several hundred species of water birds, including local and Palaearctic migrants with large population of Marabou storks. It is a major source of income of the nation through eco-tourism while the local people depend on the lake for fishing and recreation (Ash and Atkins, 2009).

There are significant numbers of congregate water birds that occur on the lake, with 20,000 birds counted along less than 25% of the shoreline in January 2009 (Fekade Daniel, 2012).

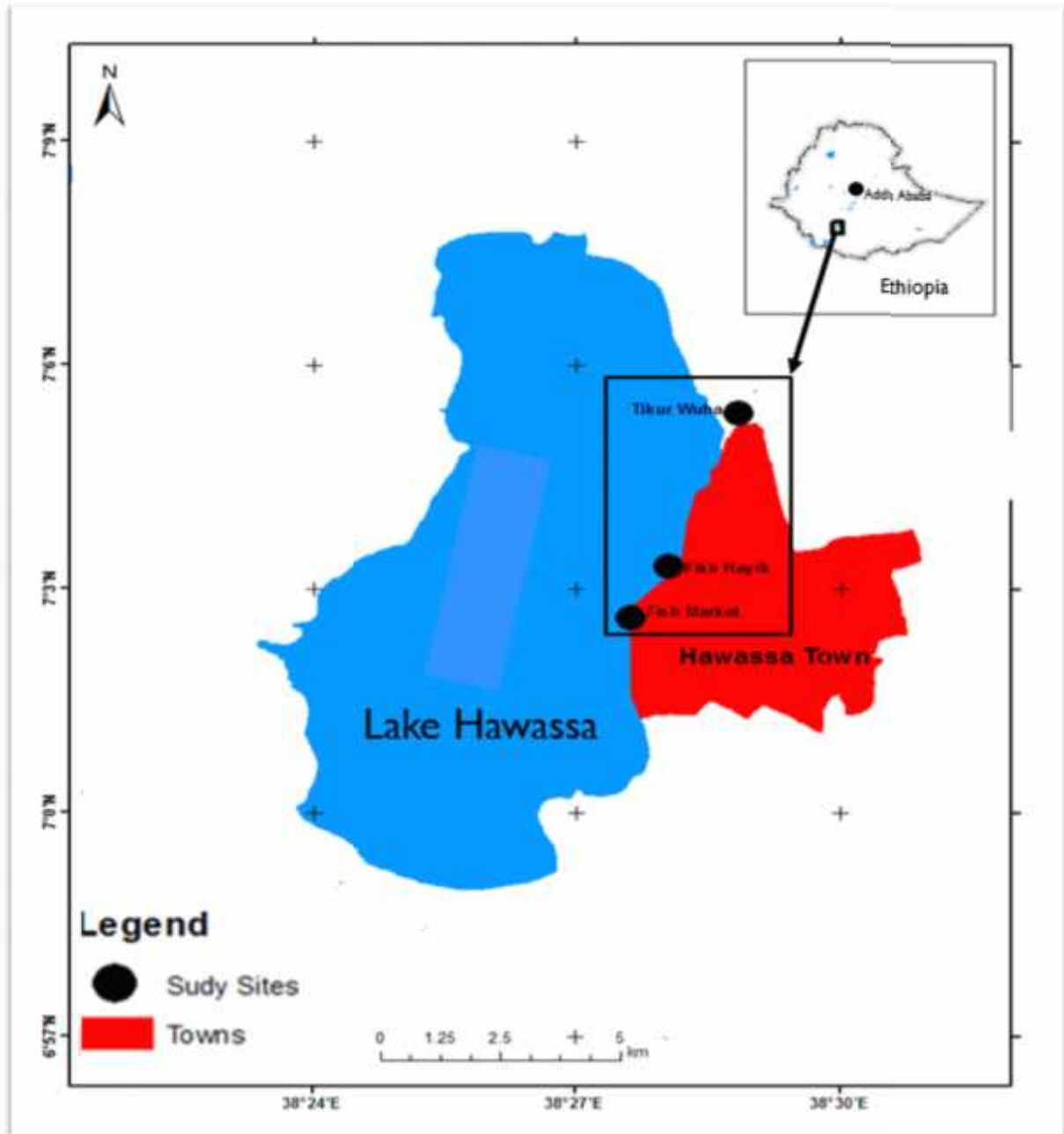


Figure 2. Map of Hawassa Town and Lake Hawassa study area.

2.2 Climate of the study area

Lake Hawassa area has a tropical climate with wet season that mainly lasts from July to September and dry season that lasts from January to March with the average monthly temperature of 23°C and average rainfall 63.66 mm (worldweatheroline 2017) . The 2017 monthly temperature and rainfall of Hawassa area is summarized in Figure 3 and 4 respectively:

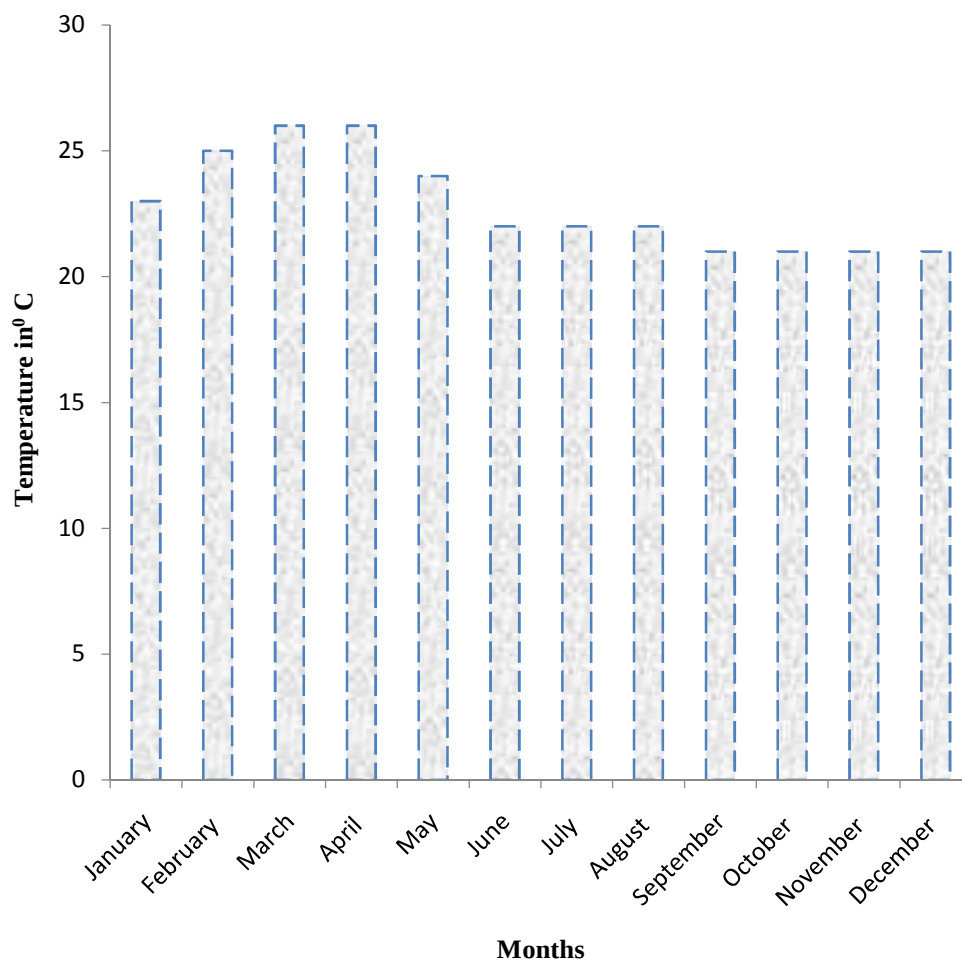


Figure 3. Monthly temperature of Hawassa (2017). (Source: worldweatheroline.com).

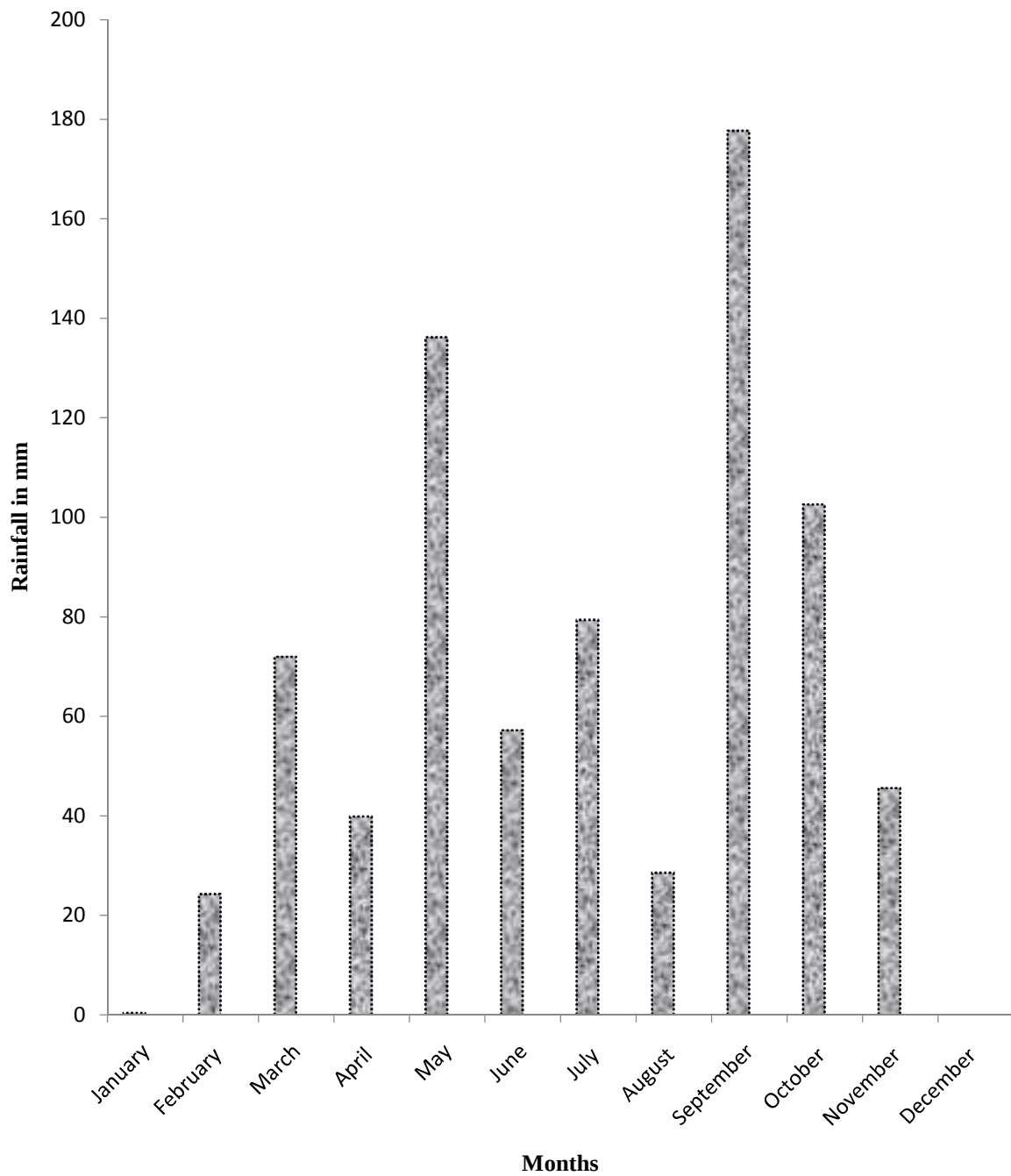


Figure 4 Monthly Rainfall of Hawassa (2017). (Source: worldweatheronline.com).

2.3 Materials

The following materials were used during the present study:

- Digital cameras, GPS, Binoculars
- Caliper, Field guide books
- Data sheets and note books
- Balance

2.4 Methods

2.3.1 Preliminary survey

A preliminary survey was carried out in July, 2017 to gather relevant information about the study area. This helped to determine the specific study sites, based on the abundance of birds during summer and winter seasons.

Detailed study was carried out from July to August, 2017 to cover the wet season for 15 days. The dry season survey was carried out from December 2017 to February 2018 for 34 days. Distribution, abundance, nesting, and roosting, feeding, and breeding behaviour of Marabou stork were studied by periodically walking within the study area on a daily basis as well as on alternative days. Census data were collected twice a day, morning (09:30 – 11:30 h) and late afternoon (15:30 - 18:30 h).

Marabou stork was observed using naked eyes and binoculars for better identification as well as hand tally during counting (Plate 2). Digital camera photographs were also used for further confirmation of the structure. Field data sheet was used to record the necessary information.



Plate 2. Counting the number of Marabou stork at fish market (Photo: by Misgana F., Aug. 16, 2017).

2.3.2 Basic counts

Bird count was carried out to identify the population size, detect changes in population size and to determine distribution by comparing the two seasons. Marabou stork can be directly counted observing breeding colonies, and at roosts, flocks, and Leks. Point count method was used walking along the shore of the lake and standing at a particular point for a fixed time by direct

observation using naked eyes and through binoculars to observe their approximate age group and feeding behaviour.

2.3.3 Feeding ecology

To collect data on foraging behavior of the Marabou stork repeated observations were carried out using naked eyes and camera for further confirmation of the structure and sometimes by binoculars for a better identification. The type of food item consumed, number of marabou feeding behaviour and activities during foraging were recorded for a certain time.

2.3.4 Nest monitoring

Nest monitoring was carried out to measure the reproductive success of a population, which is important for identifying changes in the birth rate by regularly checking nests for signs of hatching, fledging, or predation. It also provides extremely valuable information about the presence and location of pair, nesting behaviour, habitat selection, and nest predation by using Cameras and binoculars. The timing of breeding in relation to weather variables was studied, as well as the size of eggs, clutch number and number of chicks in relation to food availability and abundance were regularly assessed by climbing on tree. Moreover nest length, breadth and diameter were measured. Egg weight was taken and length and breadth were measured by caliper.

2.4 Data Analysis

The collected data of the wet and dry seasons of the three selected sample study sites (Fish Market, Fikir Hayke and Tikur wuha) were arranged and organized using Microsoft Office Excel and R software for analysis.

Abundance and distribution were analyzed by R studio soft ware whereas Microsoft Office Excel and R software were used to analyzed feeding behaviour and reproduction patterns of Marabou stork at Lake Hawassa.

3. RESULTS

3.1 Distribution and Abundance

There were 96 and 122 marabous storks were encountered during both dry and wet seasons across all the sites, respectively (Fig. 5). The number counted during the wet season was higher than the dry season. It was statistically significant at $P < 0.05$ ($t = 2.846$, $P\text{-value} = 0.032$).

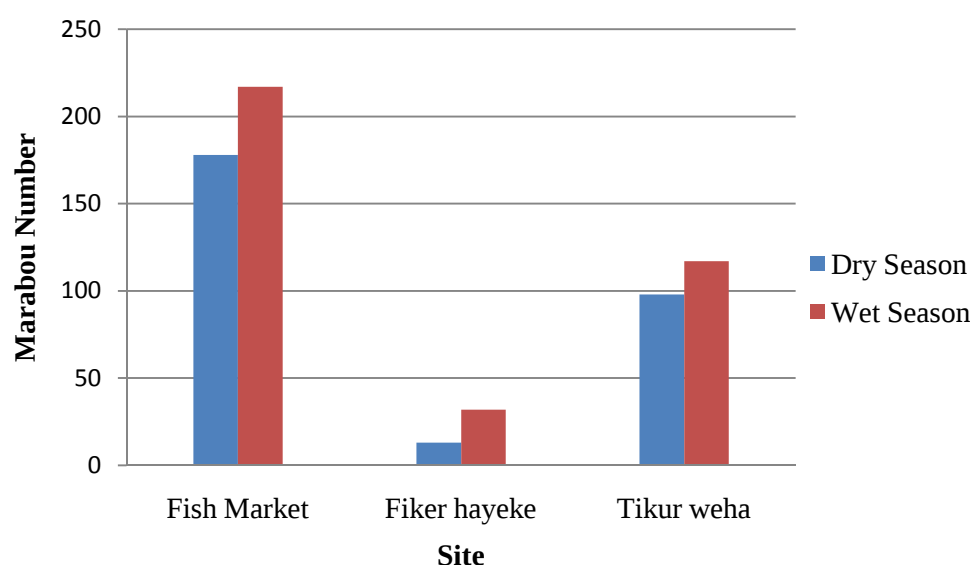


Figure 5. Distribution of Marabou stork during both seasons.

There was high concentration of adult population at fish market and Tikur Wuha where as there was no big difference of adult and juvenile population at Fikir Hayik during both seasons (Fig. 6 and Fig 7). Moreover, the differences between adult and juvenile population across all the survey sites was statistically significant at $P < 0.05$ ($t = 2.902$, $p\text{-value} = 0.03371$).

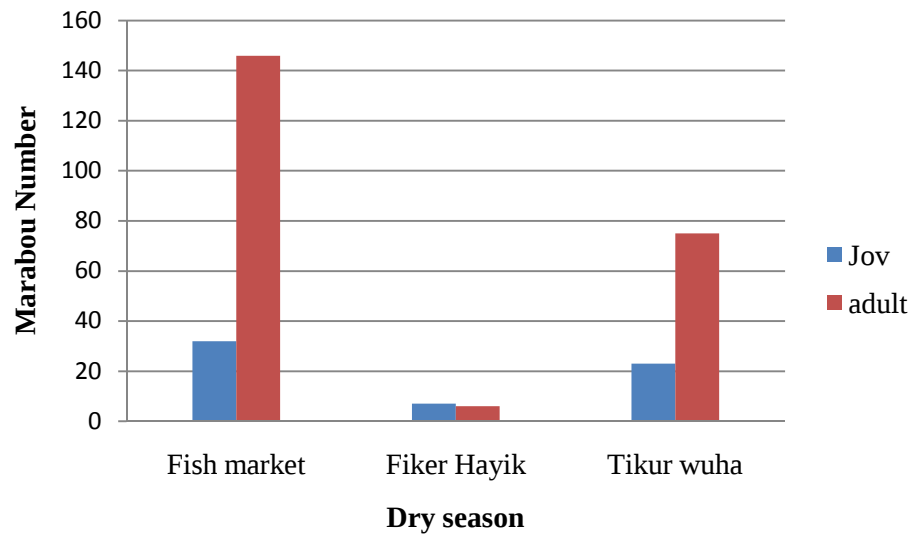


Figure 6. Marabou stork population count for all the survey sites during dry season.

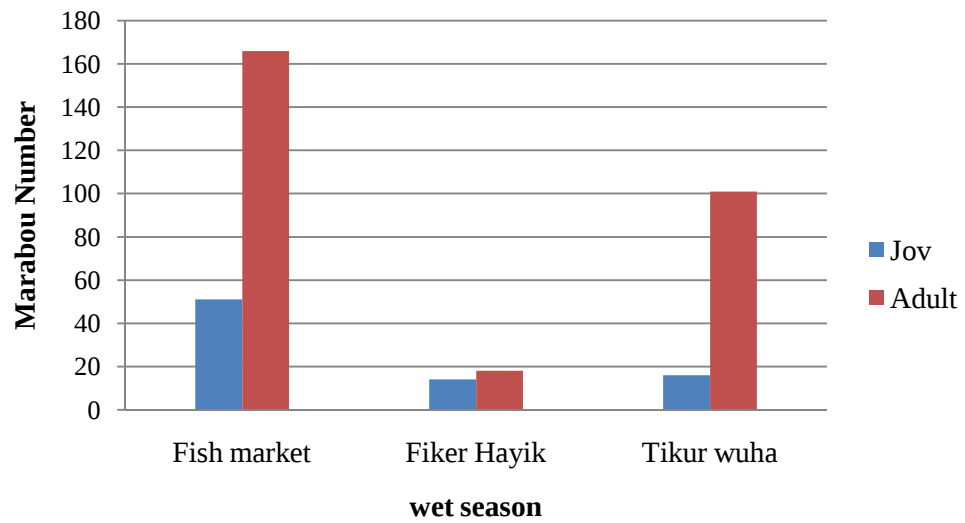


Figure 7. Marabou stork population count for all the survey sites during wet season.

Comparing the total populations of both seasons, the wet season survey produced more population of Marabou storks than the dry season. This means that on average there were 20 and 75 individual juvenile and adult marabous were encountered during the dry season respectively. The wet season recorded more figures on average 27 and 95, for juvenile and adult population, across all the sites respectively (Fig. 8). It was statistical significant at $P < 0.05$ ($t = 1.864$, $P\text{-value} = 0.02108$).

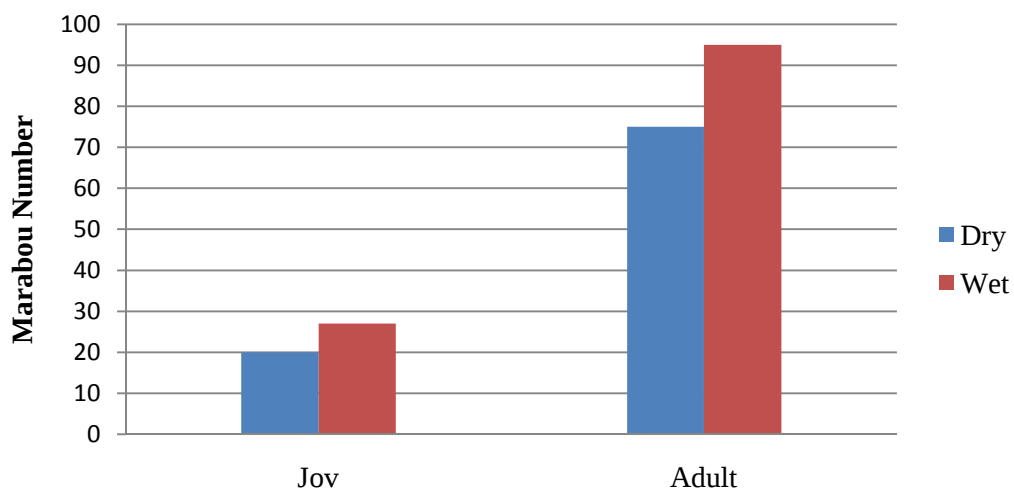


Figure 8. Juvenile and adult population of Marabou stork during both seasons.

3.2 Feeding Behaviour

During the observation period many of them were scavengers and fed in groups on scraps, carrion, worm, insect and frog. Food items of Marabou storks during dry and wet seasons are given in Table 1. The result illustrated that the percentage of Marabou feeding on fish scraps was (35%,) carrions (27%), insects (13%) worms (12%) and frogs (11%).

Table 1. Number of Marabou stork eating during wet and dry seasons.

Frequency of eating different food items						
Season	Insect	Worm	Frog	Carrion	Scraps	Total
Dry	96	91	86	214	233	720
Wet	64	65	55	116	201	501

The two study sites Fish market and Tikur wuha had more feeding activities where as Fikir Hayik had less food consumption (Fig. 9). This shows that the feeding activities of Marabou stork were based on the type of habitat. Fish market and Tikur wuha had more fishing activities resulting in high feeding process.

During the observation period Marabou storks fed in group on fish scraps at Tikur Wuha, carrion walking on the lake shore at Fish Market, and insects walking on the ground Fikir Hayik, during wet season. Different patterns of feeding processes are given in Plates 3 a-c.

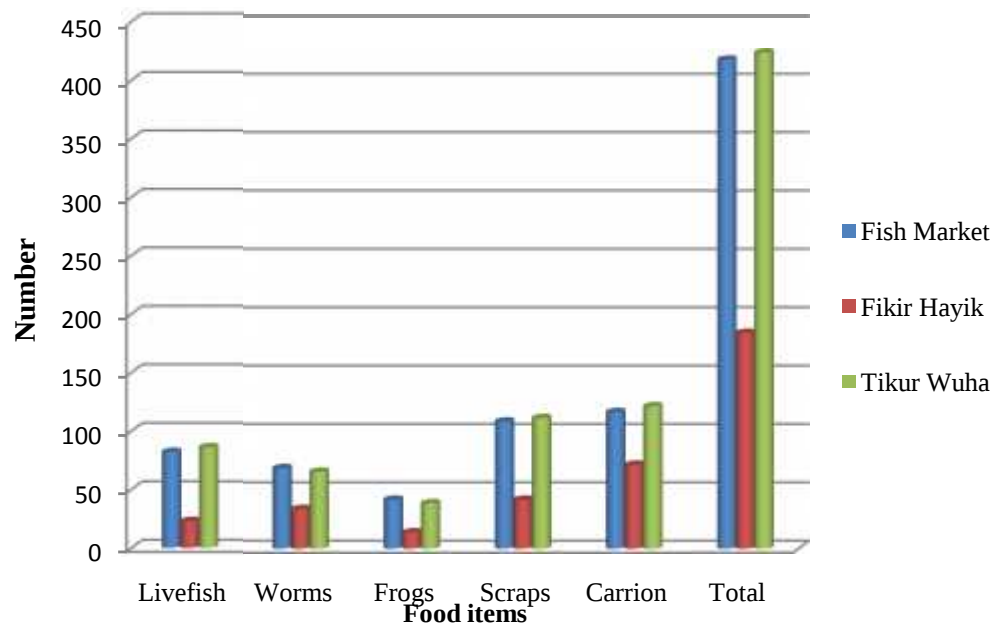


Figure 9. Food items of Marabou stork at all study sites.



Plate 3 a. Marabou feeding on scraps at Tikur Wuha during the wet season (Photo: by

Bethlehem G., Aug.18, 2017).



Plate 3 b. Marabou feeding on carrion walking on the lake shore at fish market during the wet season (Photo: by Misgana F., Aug.18, 2017).



Plate 3 c. Marabou feeding on insects walking on the ground at Fikir Hayik during the wet season (Photo: by Bethlehem G., Aug.18, 2017).

3.3 Habitat Association

Marabou storks associate at different places including perching on house buildings (Plate 4 a), walking on the main road (Plate 4 b) and communally roosting on the top of *Acacia* trees (Plate 4 c). Others walk at lake shore (Plate 4 d) to search for food. Some roosted on the ground and other walked on the ground for foraging (Plate 4 e).



Plate 4 a. Marabou roost on house building.



Plate 4 b. Marabou walk on the road at Fikir

Hayik.



Plate 4 c .Marabou roosting on *Acacia* tree around the fish market during the night and wet season (left) and day time during the dry season (right). (Photo: by Misgana F., 2017).



Plate 4 d. Marabou at lake shore

Plate 4 e. Marabou roosting on ground at Tikur Wuha

(Photo: by Misgana Fanta Aug.19, 2017).

3.4 Reproduction pattern

3.4.1 Breeding

The breeding season of Marabou is during the dry seasons. They breed in colonies of 15-40 on a single tree. First the male occupies the place and the female pins the male. Once they pair the male begins to build the nest on the top of *Acacia* tree by collecting coarse material like dry stick from other branch of tree. The female collects soft material like wet grass and branches of leaves to create a favourable environment for their chicks (Plate 5 a). The female then lays 2-3 eggs. Both parents share in guarding and incubating the eggs from 29-31 days. Hatching was not synchronized and it takes two or three days. Marabous take long period of 124 days from hatching to fledging. The first flight out of the

nest takes 90-110 days. Both parents care and feed their chicks by regurgitating food items on the floor of the nest and sometimes into the mouth of the chicks.



Plate 5 a. Marabou building nest by using branches of leaves on *Acacia* tree
(Photo: by Bethlehem G., Dec.11, 2017).

3.4.2 Nests

The nests of Marabou were large open platforms of dry sticks, branches and twigs lined with leaves and grasses (Plate 5 b). They were seen using their old nest occasionally. Nest materials were gathered from the area surrounding the nest site. However, the nests were built approximately 1km away from the study site. Height, diameter and depth of the nests are given in Table 2. The mean height of the nest from the ground surface were 17 m, the depths 22 cm and the diameter 101 cm.



Plate 5 b. Nest of Marabou near to the main road of Hawassa Lake (Photo: by Misgana F., Dec.11, 2017).

Table 2. Nests Morphometry

Nest no	Nest place	Elevation of the Lake(m)	Height from the ground (m).	Depth (m)	Diameters of the nest(m)
N1	Near to road	1682	15	0.27	1.06
N2	Near to lake	1683	19	0.18	0.93
N3	Lakeview hotel	1685	17	0.23	1.04
Mean			17	0.22	1.01

3.4.3 Eggs

The female lays 2-3 eggs during the dry season based on the availability of food (Plate 6). The length, width and weight of eggs are given in Table 3. The mean numbers of eggs laid were 3. The length of the egg was 54 mm, the width 79 mm and the weight was 124 g.



Plate 6. Clutch size of Marabou stork (Photo: by Kaleb F., Dec.12, 2017).

Table 3. Marabou stork eggs Morphometry.

Nest no	No of eggs	Colour	Length(mm)	Width(mm)	Weight(g)
N1	2	White	55	80	123
N2	3	White	53	78	126
N3	3	White	55	80	124
Mean	3	-	54	79	124

3.4.4 Hatching

The body of the newly hatched chicks is bare except for few downy feathers. Generally, the body is white with a few black spots. The beak is red with scattered black spots. The eyes were open and black in colour. The legs are long, devoid of feathers and red in colour. The neck and tail were devoid of feathers while the head was covered with little downy feathers. There was no change in colour for 15 days .Thirty days old chicks were covered with white downy feathers. The dark spots disappear after 15 days. In 45 days the chicks were generally covered with white downy feathers but the black feathers start to grow on the wings and back. The beak colour changes from red to pink. After forty five days the chicks become fully fledged adults. The upper body colour gradually changes to black with green gloss on the upper parts with white underparts and a pink beak. Wings were covered fully with feathers and the chicks start flapping their wings. Chicks at the age of more than 45 days, nearly reach adult size and become very aggressive. They use their beaks to inflict deep wounds when handled (Plate 7 a- e).



Plate 7 a. Newly hatched Marabou stork chicks (Photo: by Kaleb F., Dec.12, 2017).



Plate 7 b. Chicks of 15 days-old Marabou Stork (Photo: by Kaleb F., Dec.28, 2017).



Plate 7 c. Thirty days old (Left) and Forty five days (Right) Marabou stork chicks.
(Photo: by Erimiyas T., Jan. 2018).



Plate 7 d. Fully fledged Marabou stork (Photo: by Bethlehem G., Jan. 2018).



Plate 7 e. Fully developed Marabou stork (Photo: by Misgana F., Jan. 2018).

4. Discussion

Birds are adapted to withstand various environmental conditions from the hot tropical regions to Palearctic zones. These wide limits of tolerance and adaptability allowed them to occupy a large number of habitats. Flamingos, ibises, herons, Storks are the most important birds species at Lake Hawassa , but there are also good populations of catfish and Barbus (Fekade Daniel, 2012). These wetland habitats are attractive to various species of birds for feeding and drinking. These species of birds included both resident and Palearctic migrants. The resident species usually breed during the rainy season while the migrant species breed in their Palaearctic countries and spend the winter season in warm African countries rich in various kinds of food.

Variations were observed in the number of Marabou storks recorded during the wet and dry seasons. According to Pattnaik (2014), the populations of Marabou storks 316 and 589 were counted during the dry and wet seasons, respectively. The present investigation revealed 289 and 366 Marabou storks during the dry and wet seasons, respectively. The number of birds was found to be more during the wet season. This might be related to habitat suitability for foraging, other environmental factors and migration. Richardson (1998) had noted that migration greatly alters bird population by changing both the number and composition. Most of these variations were observed in July during the rainy period.

The high difference in habitat composition of the area during the dry and wet seasons could contribute to the effects of seasons on bird abundance. MacArthur and Pianka (1996) stated that modification of the natural environment affects the relative abundance of species. Moreover, as noted by Monadjem *et al.* (2008), Marabou storks are known to move large distances. Similarly, large movements in other large colonial breeding scavenging birds were recorded in Namibia (Hertel, 1994). Similar situations might also contribute to variations in the abundance of birds in the present study area.

According to Monadjem *et al.* (2008), the habitat of the marabou storks includes wetland and arid area of Africa. Most of their activities are in open dry savannas. They are also found near swamps, riverbanks and lakeshores especially during searching food for the young, fishing villages and rubbish dumps. In eastern and southern Africa, they are commonly found around carcasses, in association with other scavengers (Brown *et al.*, 1982). They were observed around lake shore in Hawassa town, concentrated around human inhabiting areas. Hancock *et al.*, (1992) also indicated that Marabou storks respond to increasing urbanization by adopting a scavenging life style and cosmopolitan diet in urban areas. This preference might be related to their feeding habit or availability of food such as fish scraps, frogs, insects, carrions, and worms around the lake shore and carcasses at waste dumping areas near the town. The other reason might be to avoid predators that prey on their eggs and young. Marabou is a common scavenger in regions where game is common. The feeding site of Marabou storks is usually around lake shore where fishermen remove fish scraps and dump waste around the town. Season has a significant impact on food availability and preference by birds.

Marabou Stork breeds during the dry season. The choice of sites for breeding colonies seems to be determined primarily by the availability of food. This might be the reason for observing Marabou storks breeding and living in the town and near the lake shore where food was available. It is also advantageous to breed as close as possible to the food source.

According to Pomeroy (2001), the main breeding population of the Marabou stork is centered in northeast Africa (Ethiopia-Somalia) between September-November. The present investigation also revealed that more breeding sites were observed during this period in the study area. The study further showed that the specific time of breeding in Ethiopia was during the dry season extending up to January. Even if these birds breed in town, they prefer tree type and height for nesting and resting. According to Burton and Burton, (2002), Marabou storks breed on high trees and cliffs which may be 30 - 40 m high. In this study, Marabou storks breed on a single *Acacia* tree, 12 - 17 m high from 10 - 20 individual roosted on a tree. Marabou storks breed in high places to protect their nestlings from predators. The breeding season varied in different regions of Africa. During this study, both male and female Marabou storks shared nest building and collected building materials. Marabou storks were monogamous birds and the bond between a pair was not broken before their nestlings were fully grown. The female laid 2 - 3 eggs, but Pomeroy (2001) reported that the female laid 2 - 5 eggs which were laid at two day intervals at the end of the rainy season. Incubation of the eggs was shared by both parents and the eggs on average hatched in 29-31 days. This agrees with the present study.

5. CONCIUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This study addressed the population status, feeding ecology and reproduction patterns of Marabou stork (*Leptoptilos crumeniferus*) in the study area. The presence of ample resources, especially adequate food supply can increase the abundance of bird species at a given area. Chace and Walsh (2006) indicated that birds respond to change in vegetation composition and structure, which in turn affects their food resources. Managed areas tend to increase plant species richness or increase in total vegetation cover, leading to the presence of diverse avifauna. The lake shore of Hawassa provides a suitable habitat for water birds to get food and water resources. These factors attract large number of bird species including Marabou storks. However, as observed during the study period, large parts of the natural resources like water, soil and vegetation around the lake have already been degraded and polluted. As a result, the threats to birds in the study area are highly associated with the fragmentation and habitat loss due to anthropogenic factors. However, the local people of the study area are relatively supportive and cooperative to work for the sustainable development of the lake. However, cultivation, pollution, fire, poaching and grazing should be curtailed to minimize the effect of avian species diversity. As birds are very important for various purposes, further research is important to understand the biological interaction of urban as well as wetland birds in the area.

5.2 RECOMMENDATIONS

The following recommendations are forwarded based on the findings of the present study:

- ❖ The area is over crowded with people. Alternative mechanisms should be identified to reduce the number.
- ❖ Increase the awareness of the community who practice fishing activities on how to use it properly to minimize anthropogenic factors.
- ❖ There should be coordination between environmental protection offices of Hawassa town and community to control the pollution of lake for sustainable development.
- ❖ There should be enough gap in the system of exploitation. Unless sustainably used, the fish population will be affected.
- ❖ There should be protection to stop sale of Marabou stork eggs. It will lead to population decline.
- ❖ There should be coordination between cultural tourism offices of Hawassa town to work with the administration to attract the tourists.
- ❖ Establishment of protected areas for birds should be carried out with emphasis on the participation of the local people.

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APPENDIX 1

Data Sheet 1 Distribution and Abundances

Survey area _____ Date _____ Season _____

Habitat location and description

Start time (24hrs) _____ **End time (24hrs)** _____

[illegible]

APPENDIX 2

Data Sheet 2 Breeding Behaviors

Survey area _____ Date _____ Season _____

Habitat location and description

Start time (24hrs) _____ End time (24hrs) _____

Nest No	Habitat type	Site and GPS point	Parents observed			Nest type/ on Tree					Total
			M	F	Both	Acacia	Ficus	Ground	Tree height	others	
N1											
N2											
N3											
N4											
N5											
N6											
N7					49						

APPENDIX 3

Data Sheet 3. Nesting material used, clutch size and condition

Survey area _____ Date _____ Season _____

Habitat location and description

Start time (24hrs) _____ End time (24hrs) _____

Nest No	Habitat type	Site and GPS point	Nesting material used				Clutch Size	Clutch condition			
			Grass	Stem	Leaf	unknown		Egg size	hatchings	chicks	Total
N1											
N2											
N3											
N4											
N5											
N6											
N7											