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Diurnal Activity Patterns and Foraging Behaviour of Wattled Ibis (*Bostrychia carunculata*) in Menz-Guassa Community Conservation Area (MGCCA)

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

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Acronyms

ANOVA:	Analysis of Variance
BLI:	Bird Life International
EBI:	Ethiopian Biodiversity Institute
EWNHS:	Ethiopian Wildlife and Natural History Society
GPS:	Global Positioning System
IBAs:	Important Bird Areas
IUCN:	International Union for Conservation of Nature
KBA:	Key Biodiversity Area
MGCCA:	Menz Guassa Community Conservation Area
SPSS:	Statistical Package for Social Sciences
USAID:	United States Agency International Development

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Abstract

The present study documents the diurnal activity patterns and foraging behaviour of Wattled ibis (Bostrychia carunculata) in Menz-Guassa Community Conservation Area, Amhara Region, Ethiopia. Data were collected during the wet (August) and dry (March) seasons in 2020/2021 using scan sampling method. Repeated observations were conducted to collect data on activity patterns and foraging behaviour of Wattled ibis. Activity patterns including feeding, scanning, flying, preening, resting and others were observed. Feeding activity comprised the highest proportion during both the wet (75.5%) and dry (79.4%) seasons. The proportion of time allocated for feeding activity by Wattled ibis varied significantly with season. Also, feeding was the most pronounced activity in the three time slots; early morning, mid-day and late afternoon both during the wet and dry seasons. But, there was no statistically significant difference in time spent for feeding between the three time slots in both seasons. There was a statistically significant difference in the mean rate for flying between the three time slots of the wet and the dry seasons. However flying activity was not significantly different between seasons in the three time slots. Activities of Wattled ibis varied in different hours of the day and among the activities feeding was highly pronounced in each hour. Feeding reached peak point between 8:00-9:00 and 16:00-17:00 hours during wet and dry seasons respectively. Feeding was not significantly different between the different hours. On the other hand flying activity showed significant difference between the different hours of the day in both seasons. Wattled ibis feed only on worms and insects. Worms comprised the highest proportion during both the wet (72.3%) and dry (71.4%) seasons. There was no significant difference in the type of food consumed between seasons. But, there was significant difference between types of food consumed by Wattled ibis in both seasons. There was statistically significant difference in the probing rate between seasons and the probing rate was highest in the dry season (44/minute). Further ecological studies should be conducted to have complete ecological information of the bird and to facilitate conservation and management plans in the study area.

Key Words/ phrases: Activity patterns, Feeding, Wattled Ibis

1. INTRODUCTION

1.1. Background

Ethiopia is the largest landlocked country in Africa and one of the top 25 biodiversity rich countries in the world. According to United States Agency International Development (USAID) (2008), Ethiopia hosts two of the biodiversity hotspots of the world; the Eastern Afromontane and the Horn of Africa hotspots. The main reason for this is the altitudinal difference with the highest peak 4620m above sea level at Ras Dashen and the minimum 126m below sea level in the Afar depression (Misganaw Mola *et al*., 2021). These wide altitudinal variations have contributed to the diversity of flora and fauna of Ethiopia. As a result, over 320 species of mammals, 200 species of reptiles, 63 species of amphibians, and 145 species of fish are known (EBI, 2014). In terms of bird diversity Ethiopia is one of the top diverse countries in Africa with over 821 bird species identified so far of which 17 species are endemic to Ethiopia and 36 species are globally threatened (Bird Life International, 2021).

The astonishing avian diversity is attributed to the country's great geographical diversity, habitat diversity and climatic variability (Tariku Mekonnen and Abebayehu Aticho, 2011). To promote the conservation of birds and their habitats, 68 areas are identified as Important Bird Areas (IBAs) of Ethiopia (Bird Life International, 2021) and 30 of these areas comprise wetlands which is 41% of the total IBAs, while the rest 59% are representatives of other ecosystems (Alemkere Bezabih *et al*., 2020). Menz-Guassa Community Conservation Area (MGCCA) qualifies as an IBA with 86 bird species that belong to 35 families identified so far. The area consists of high diversity and abundance of endemics and highland biome restricted bird species (Yihenew Aynalem and Bezawork Afework, 2018). The area is known location for substantial numbers of Spot breasted Plover (*Vanellus melanocephalus*), Rouget's Rail (*Rougetius rougetii*) and Abyssinian Longclaw (*Macronyx flavicollis*) (EWNHS, 1996).

Wattled ibis (*Bostrychia carunculata*) is one of the wading bird species found in MGCCA. It is a large, brownish bird with an extensive white wing patch. The wing patch is formed by many white edged wing coverts. It has thin wattle that is about 20mm long hanging on the base of the broad bill (Hughes, 2006; Redman *et al*., 2011). The species is sometimes seen in other habitats but major part of their lifecycle is totally dependent on wetlands. It is a near endemic species

with its abundant population in the Ethiopian highlands and Eritrea. Ibises occur only in the Eastern Afromontane Biodiversity Hotspot Key Biodiversity Area (KBA) (Luis, 2020a). They are identified by IUCN as species of 'Least Concern' with little information available on its population, ecology, habitat use and breeding biology (Bird Life International, 2021).

The main objective of the present study was to quantify diurnal activities and foraging behaviour of the Wattled ibis, which is significant in understanding its life history. Activity data of animals provide relevant information on the species' natural history and ecological niche. It also reflects an important aspect of animal behaviour and ecology (Kabir *et al.,* 2013). The ecology of Wattled ibis was studied by Kalkidan Esayas in 2017 at Chelekleka Lake Bishoftu, Ethiopia. However the daily activity patterns of a species' is altered by different environmental factors such as resource availability, predation risk and interactions with other species (Ronnie *et al.,* 2015) and the magnitude of these factors vary at any elevation. Therefore in the present study the activity patterns were investigated in MGCCA which is located in the central highlands of Ethiopia.

On the other hand studying foraging behaviour is important in understanding the ways in which the species partition their resources and can help to answer a wide range of questions (Niwton and Green, 2005). Foraging behaviour of birds is not constant; indeed, they depict a diversified feeding behaviour that depends on the nature of the microhabitat, predation risk and the abundance of vegetation. Foraging behaviour is influenced by the habitat type they depend on. Individuals of the same species exposed to different types of habitats have been observed to exhibit different behaviours related to foraging (Yousaf *et al*., 2020). Hence, this study is aimed at understanding the activity patterns and foraging behaviour of Wattled ibis in MGCCA, Amhara Region, Ethiopia.

1.2. Objectives

1.2.1. General objective

The general objective of this research was to study the activity patterns and foraging behaviour of Wattled ibis in Menz-Guassa Community Conservation Area, Amhara Region, Ethiopia.

1.2.2. Specific objectives

The specific objectives of this research were

- ✓ To assess the diurnal activity patterns of Wattled ibis in wet and dry seasons in Menz- Guassa Community Conservation Area
- ✓ To assess the diet composition of Wattled ibis in Menz-Guassa Community Conservation Area
- ✓ To quantify the probing rate of Wattled ibis in Menz-Guassa Community Conservation Area

1.3. Research Questions

1. Do diurnal activity patterns of Wattled ibis vary depending on seasons?
2. Do diurnal activity patterns of Wattled ibis vary depending on time of the day?
3. What does Wattled ibis feed on during the wet and dry season?
4. Does the probing rate of Wattled ibis vary depending on seasons?

1.4. Significance of the study

The current research will help to:

- Develop knowledge and understanding of Wattled ibises activity patterns
- Reveal effect of season and time on the activity patterns and foraging behaviour of Wattled ibis

2. LITERATURE REVIEW

2.1. Physical characteristics

Wattled ibis is a large, brownish bird with an extensive white wing patch. The wing patch is formed by many white edged wing coverts. It has thin wattle that is about 20mm long hanging on the base of the broad bill (Plate 1). The bill is thick and curved structure that is used to probe into shallow water and mud when foraging. Plumage is glossed dull green and has red eye surrounded by a white ring. Both sexes are similar but, juveniles have whiter necks and duller plumage. These features distinguish ibis from its close relative Hadada ibis (*Bostrychia hagedash*). The ibis are 80cm, 32" long and weighs 1.5kg on average. The average bill and wing length are 134 mm and 353 mm, respectively (Hughes, 2006; Redman *et al*., 2011). In flight they make loud "kowrr-kowrr-kowrr" calls; this makes it easily recognizable and audible even from some distance away. The ibis usually settle in flock of 30 to 100 individuals, but it can also be see alone or in pairs. Their diet consists of worms, insects and small invertebrates. When feeding it walks probing the ground regularly (Hughes, 2006; Weldemariam Tesfahunegny, 2016).

Plate 1: Wattled ibis (*Bostrychia carunculata*)
(Source:http://www.arthurgrosset.com/africabirds/wattledibis.html)

2.2. Taxonomy

Wattled ibis (*Bostrychia carunculata*) is a species of the Order Pelecaniformes under the Family Threskiornithidae. Formerly Ibises were thought to be related to birds in the order Ciconiiformes. The family Threskiornithidae includes 34 species of large wading birds that has been traditionally classified into two subfamilies, the ibises and the spoonbills (Hancock *et al*., 1992). However, recently genetic studies are showing uncertainty on this arrangement. Accordingly additional genetic information is required to recognize a major, deep split in the family.

Redman *et al*. (2011) described five Ibis species from the family Threskiornithidae that are found in Ethiopia including Wattled ibis. They are identified by head-shape, calls and range. Most have loud diagnostic calls often given in morning or evening flights to and from roosts. The species are described below;

African Sacred Ibis, *Threskiornis aethiopicus*

African Sacred ibis is widespread and common in many habitats, including cultivated lands, often near fresh or salt water from sea level to 3000m. It differs from Wattled ibis and other ibises in being black and white.

Hadada Ibis, *Bostrychia hagedash*

Hadada ibis is common and widespread in grasslands, marshy areas and damp forest edges, as well as gardens and cultivation mainly in highlands below 2400m. It is a close relative of Wattled ibis. Their most striking difference is that Hadada ibis has white cheek stripes and Wattled ibis has a brown head and wattles.

Glossy Ibis, *Plegadis falcinellus*

Glossy ibis is the most widespread ibis species breeding in scattered sites. It is common and widespread, in wetlands of all type. Can be easily distinguished from Wattled ibis by their physical characteristics.

Northern Bald Ibis, *Geronticus eremita*

Northern Bald ibis is very rare and endangered Palearctic winter visitor, historically recorded from Eretria and Central Ethiopia, with single old record from North-West Somalia. Unlike Wattled ibises Northern Bald ibises prefer dry rocky areas often along sides of river valley.

2.3. Distribution and Habitat

Wattled ibis occurs all over Ethiopian highlands at altitudes ranging from 1,500 to 4,100 m, where it inhabits highland river courses with rocky cliffs, and montane habitats including grasslands, marshes, swamps, and alpine moorlands. They are also seen in open country, cultivated land, plantations, city parks, and open woodland (Hughes, 2006; Redman *et al*., 2011). During rainy seasons it can be seen in green areas and lawns of down town Addis Ababa and this shows that the species has become well adapted to anthropic landscapes and conditions (Hiwot Hibste, 2007). It has also been recorded on the coast of Eritrea (Fig. 1) (Bird Life International, 2021). Wattled ibises are generally sedentary, however some local, altitudinal movements have been noted (Vivero, 2001).

Wattled ibises are located in most of Ethiopian Protected Areas and National Parks. In addition, they are also found in; Kuni-Muktar, Debre Birhan, Gosh Meda, Wondo Genet, Gefferssa Reservoir, Tefki wetland, Lake Awasa, Choke Mountain, Sululta Plains, Ankober, Langano, Mount Zuquala, Lake Ashenge and Grat-Kahsu Forest (Weldemariam Tesfahunegny, 2016).

Figure 1: Distribution map of Wattled ibis (Source: Bird Life International, 2021)

2.4. Foraging Behaviour

Foraging behaviour refers to the range of activities exhibited by organisms in their search for food. These activities include searching, movements to capture the food, and handling of the food before ingestion. Birds have unique body adaptations and a range of described behaviours different from other animals foraging behaviour. Many bird species are known to exhibit bimodal feeding pattern, where there maximal feeding is in the morning and late afternoon. This is because of their high energy requirements in the morning to start their daily activities and the overnight energy requirement of the birds (Yousaf *et al.*, 2020). They are opportunistic, intelligent feeders and often use a variety of feeding techniques, adapting their methods to best suit the current conditions of their habitat and prey. During feeding, individuals in a flock look their surrounding actively. When they spot any sign of danger they give a call signal and fly away from their feeding and perching sites. In the meantime, if any one of them flew, others follow and the remaining ones will be in alert. If the intruder does not approach, they continue their usual activities. Otherwise, they abandon the site (Ali and Asokan, 2015; Hiwot Hibste, 2007).

Avian foraging behaviour is distinguished by their diet and bill morphology. These bill morphologies are adaptive to a specific type of foraging technique (Barbosa and Moreno, 1999).

Types of avian foraging behaviour include grazing, jabbing, picking, leaping, and probing. Among these probing is observed in species with long and curved bills and this makes it possible to inspect a greater volume of sediment (Norazlimi and Ramli, 2015). Accordingly, Wattled ibis possess a long and curved bill that is modified for probing. In addition Wattled ibises also show unusual foraging strategies, for instance they forcefully pull out grass and collect prey material from the root region (Kalkidan Esayas, 2017).

Wattled ibis feed on insects, worms and small invertebrates. They also consume other food items, such as frogs and small mammals, but with very small contribution to their annual diet (Brown *et al.*, 1982). Ibises forage in different habitats like forest glades, shrub land, marshes, open alpine moorlands, croplands, and open grasslands. However their habitat preference is dependent on the season. During dry season they prefer grassland, moist ground of plantations and settlement area. On the other hand during the wet season they are restricted to muddy microhabitats following the margin of the marshland. The Wattled ibis is a gregarious species flocking in groups of 30 to 100, but it is also seen feeding alone (Vivero, 2001; Weldemariam Tesfahunegny, 2016).

Studies showed that type of habitat in which species forage influences foraging success and foraging success of Wattled ibis was found to be high in the forest habitat and were more than twice as successful at obtaining food items as in any other habitat (Kalkidan Esayas, 2017). Another study also showed that Wattled ibis were restricted to densely vegetated muddy habitats foraging in large aggregation. These habitats are rich in prey items and they rescue the species from predators by providing cover (Murray, 2009).

2.5. Diurnal Activity Patterns

Diurnal activity pattern is the time allocation of animals performing behavioural activities that are important for their survival and reproduction (Ali and Asokan, 2015). It reflects a combination of factors such as an individual's physical condition, social structure and environmental conditions. Studying the time allocated to various behaviours is therefore important in understanding the species ecological needs and the pressures acting upon individuals. In addition when coupled with habitat analysis it is useful in formulating suitable conservation strategies (Frey *et al*., 2017; Ronnie *et al*., 2015).

Activity patterns of animals vary in different hours of the day and months which help them to avoid inter specific conflicts with other animals in the same feeding and breeding ground (Burger, 1978). Thus daily activities of a species can be influenced by an individual's need and its interactions with organisms. Moreover activity patterns are influenced by several other factors, including weather, season, and habitat. The diurnal activity patterns often vary among and within species; as a result, these help us to study the life history and ecological adaptations of animals (Ali *et al*., 2010; Ali and Asokan, 2015).

Birds exhibit various behaviours like feeding, resting, preening, scanning, flying and fighting in response to its daily needs. These activities are subject to temporal variations, for instance resting is a major mid-day activity of most birds in order to minimize the heat load on a bird subject to high environmental temperatures. After mid-day, when the temperature is low, resting period diminishes and feeding activity starts taking place (Hiwot Hibste, 2007). The time allocated to these activities determines the activity patterns of the species. Activity patterns of birds is influenced by type of weather, breeding season, habitat type, time of the day, food requirement of the species and food availability (Ali *et al.,* 2010). Comparatively, the availability of food and the interference of human are more influential factors than weather in affecting the activity of birds in the area. However, they prefer sunny and warm days than dull and cold weather. Activity patterns often vary among and within species. But in general the most significant and attentively observable activity of birds is their feeding habit as energy requirements are the driving factor in the time allocation of animals (Hiwot Hibste, 2007).

The time and amount of energy a bird spends performing different activities inevitably influence its survival. The time allocation of birds varies greatly depending on the type of habitats they inhabit and food they eat (Bellanthudawa *et al.,* 2019). Just like most birds Wattled ibises are diurnally active and have small home ranges. Ibises spend the highest amount of their daytime in foraging than other activities (Gary, 1990; Kabir *et al*., 2013).

2.6. Nesting Behaviour

Nest building requires a significant amount of time and demanding activity of birds. It is one of the most important activities of birds as it provides birds with support, insulation, concealment from predators, and shelter from rain (Buger and Miller, 1977). Moreover nest plays important

role in brooding i.e. egg laying and raising their young ones. The nesting behaviour of avian species has evolved over ages in accordance with the climate, habitat, size, presence of predators, clutch size, physiology, and chick development patterns (Kushlan, 1976).

Nests can be built on the ground, on trees, in marshes and on cliffs depending on the nesting habit of the species. Wattled ibises usually nest on rocky cliffs, over bushes and hanging on walls. Reports also show that ibises nest on top of trees and ledges of buildings (Luis, 2020a). An ecological study by Kalkidan Esayas (2017) showed that Wattled ibises usually prefer forest and farmland habitats for nest building. They also nest colonially at settlement, bare land and swampy irrigated vegetation during breeding season. Familiarity to an area, predator avoidance and food availability are possible factors affecting nest site selection. The study also showed that Wattled ibises often reuse their nests, thus they can save energy required for nest building. In addition pre-laying period is short when old nests are re-used and this intern facilitates repeated breeding in the same year.

Nest building materials vary widely. Some species use small stones to line up their nest others build their nest of dirt with or without plant material. Sticks, leaves, algae, rootlets, and other plant fibers are used alone or in combination. Ibises build their nest with branches and sticks, lined with grass and strips of bark. In some nests artificial items such as wires, nylon rope and cable are found (Luis, 2020a). At forest they build their nest with loosely bound material, resulting in nests falling into pieces towards the end of the breeding season. As ibises occur in highland areas their nest are located to the east for maximum exposure to morning sun. It is reported that both male and female ibis take turns in guarding the nest site until the chicks are large enough to defend themselves (Gary, 1990; Luis, 2020a). Wattled ibises nest in small to large colonies. A survey in Bale Mountains show that they nest in colonies of 500 and above. When breeding colonially nests are placed on the eastern slopes of rocky cliffs, often up to 3,000 m in altitude. On the other side when breeding in solitary pairs or small groups nests are more likely to be placed on the tops of trees at lower elevations (Hughes, 2006).

2.7. Breeding Ecology

A wide variety of breeding systems are found in birds. Mating system and the means by which parental care is provided are issues that determine the breeding system of a species (Urban,

1974). The type of breeding system is influenced by their evolutionary history and other aspects of their biology. Breeding success of birds is determined by the hatching success, fledging success, reproductive success and nest success (Emily, 1974; Kopij, 1997a; Kopij 1997b).

Wattled ibises breed during the short rainy season between March and April and in the more substantial rains of July and September. Occasionally ibises also breed during the dry season in December and breeding activities are mostly observed after the rainy season, when plenty of food is available. At lower altitudes, breeding activity is mostly observed in October. Ibises usually breed colonially; it may also nest in solitary pairs or smaller groups (Weldemariam Tesfahunegny, 2016).

Wattled ibises normally lay two to three dirty-white, rough-shelled eggs. Both parents incubate the eggs in shift, and after hatching feed the young by partial regurgitation. Two or three weeks after hatching, the young ones leave the nest, often forming creches but returning to be fed by the parents (Weldemariam Tesfahunegny, 2016). The adult ibis mainly feed on aquatic insects, insect larvae and other small aquatic animals. While chicks mainly feed on worms and insects on the aquatic habitat. After fledging, they will start foraging insects on dry land during periods of aquatic prey shortages (Kopij, 1999; Luis, 2020a).

In breeding seasons, Wattled ibises gather in huge colonies near water. Males engage in extra pair copulation with other females to increase their reproductive success and they pirate food from unmated females and juveniles during this season. Chick in a clutch hatch usually at 1 day interval and hatching takes place throughout the day, with its peak being at the afternoon. Their life span is approximately 10 to 12 years (Hughes, 2006; Kalkidan Esayas, 2017; Luis, 2020a).

2.8. Population Size

The population of Wattled ibis is estimated to number from 670 to 17,000 mature individuals (Bird Life International, 2021). No reduction in numbers or any obvious threat is reported (Weldemariam Tesfahunegny, 2016). Therefore, Wattled ibis is not considered to be one of conservation concern. However more information is needed on this species' distribution, population status and natural history. Population monitoring is also needed in view of the recent status.

This species has a very large range, and hence does not approach the thresholds for Vulnerable under the range size criterion. The population trend is not known, but the population is not believed to be decreasing sufficiently rapidly to approach the thresholds under the population trend criterion (>30% decline over ten years or three generations). The population size may be small, but it is not believed to approach the thresholds for Vulnerable under the population size criterion (<10,000 mature individuals with a continuing decline estimated to be >10% in ten years or three generations, or with a specified population structure). For these reasons the species is classified as Least Concern on the Red List Category (Bird Life International, 2021).

2.9. Threats

According to a study by Hughes (2006) in the Bale Mountains National Park Wattled ibises are exposed to two major threats: overgrazing and tree-cutting. In addition potential threats like soil erosion, conversion of land to agriculture and extraction of ground water were identified. However Wattled ibises are not believed to be persecuted and the people around these area live in harmony with the birds.

In another study by Luis (2020b) Wattled ibis populations have been studied at an agricultural upland in Arsi and semi-urban population at Bishoftu. The study found that in both populations' legs of individuals entangled in synthetic string and other bizarre materials (Plate 4). Moreover a mass of synthetic strings were found entangled in their phalanges and uses plastic debris in their nests. This indicates that there is a risk of ingestion of plastic debris leading to the reduction of their breeding success. However, there are no references to the potential threats of plastic debris but, these observations should encourage further research into the effects of plastic debris.

Plate 2: Wattled ibis with leg entangled in plastic material (Source: Luis, 2020b)

3. MATERIALS AND METHODS

3.1. Description of the study area

Menz-Guassa Community Conservation Area (MGCCA) is located in Menz- Gera Midir Woreda, North Shewa Zone, Amhara National Regional State. The area lies between 10° 15′ – 10° 27′ N and 39° 45′ – 39° 49′ E (Fig. 2) (EWNHS, 1996).

It is one of the key biodiversity areas located in the central highlands of Ethiopia at the edge of the escarpment of the Rift Valley. MGCCA covers an area of 98km^2, and it is one of the oldest known common property resource management in Sub-Saharan Africa. The area originated from an old system known as "Qero" that is a community based natural resource management (Endalkachew Teshome *et al.*, 2020). The altitude varies from 3200 to 3600m asl and the area serves as a water catchment for many streams and rivers draining into the low lying areas of North Shewa. It forms the watershed between the Nile in west and Awash River systems to the east and thus plays an important hydrological function. MGCCA is given its name from the high altitude Afro-alpine Festuca grassland, or 'Guassa" grass (EWNHS, 1996).

3.1.1. Climate

The high altitude plays a major role in determining the climate which belongs to the wet agro-ecological zone (EWNHS, 1996). The dry season is characterized by frequent frost and fog. While the wet season is characterized by a combination of rainfall, frequent fog and occasional snow, moreover there is a persistent rainfall in July and August making the season least favorable (Endalkachew Teshome *et al.,* 2020). In the driest months (December- February) the daytime temperature can rise to 23°C while at night it can fall to -10°C. However in the wet season the temperature variation is less with a daytime temperature of 12 °C and a nighttime temperature of 3 °C. The annual rainfall for the area is expected to ranges from 1200mm to 1600mm per year (Solomon Ayele and Demel Teketay, 2017).

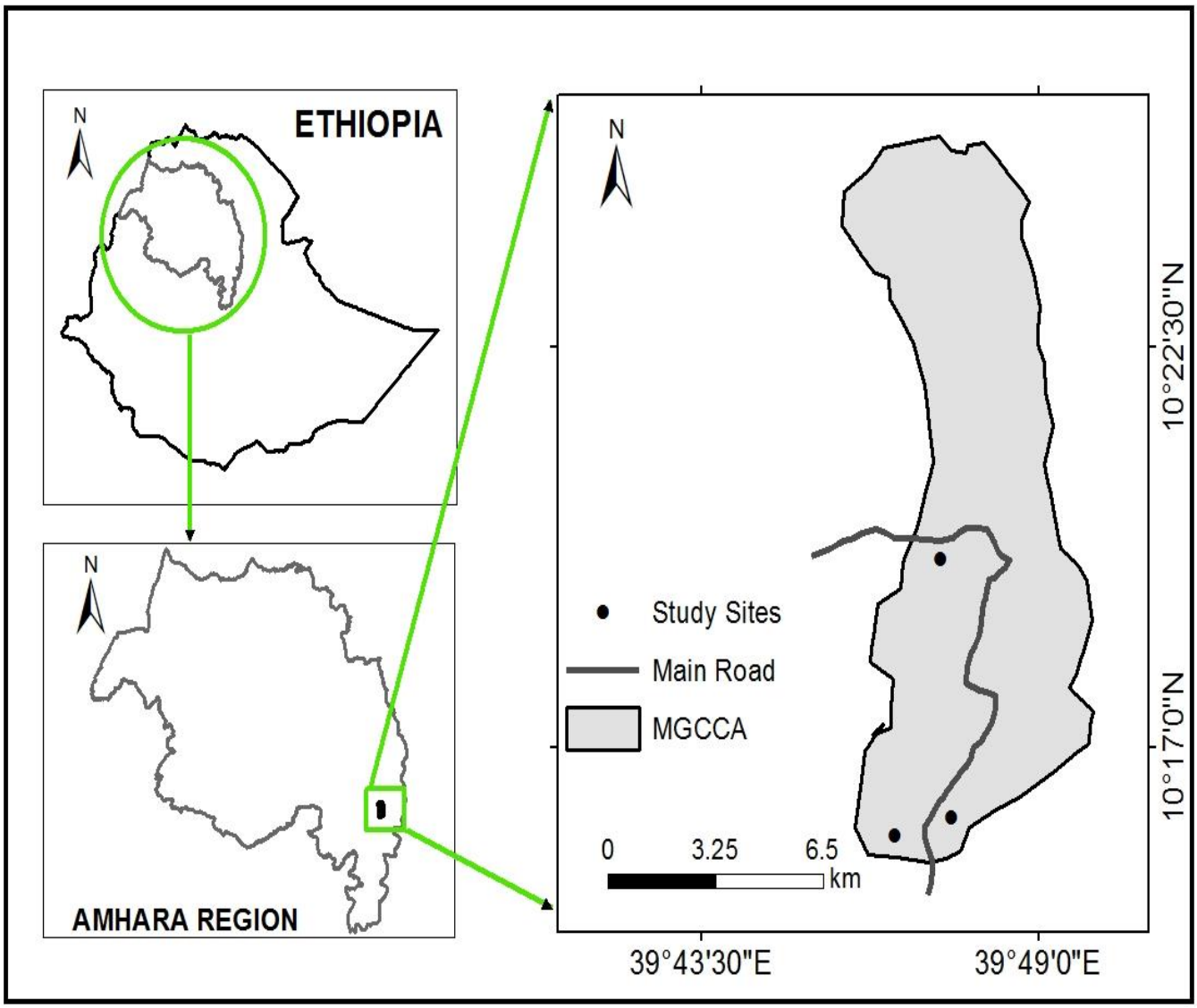


Figure 2: Map of the study area

3.1.2. Topography

The rugged mountain plateau of MGCCA is crosscut by gorges and river valleys running westwards. The eastern edge of the Guassa Area falls away abruptly as cliffs drop into the Great Rift Valley. The area is known by hills and valley bottoms dispersed with swamps and open areas of montane and afro-alpine grassland that varies with altitude making it attractive tourist site (EWNHS, 1996; Solomon Ayele and Demel Teketay, 2017).

3.1.3. Flora

MGCCA is an important component of the Afro-Alpine habitat of Ethiopia with different habitat types namely, Euryops Alchemilla shrubland (22%), Fes- tuca grassland (20%), Euryops-Festuca grassland or Mima mound (16%), and Erica moorland (10%) (Zelealem Tefera *et al.,* 2005). The vegetation of the Guassa area is characterized by high altitude Afro- alpine vegetation, which supports important and endemic plant species. There is a diverse herb complement in the area including Jibra (*Lobelia rhynchoperalum*), Asta (Erica), everlasting flowers (Helichysum spp.), Toseign (Thymus spp.), lady's mantle (Alchemilia spp.) and Guassa (Festuca spp.) from which the name of the area is derived. Besides the Guassa grass is highly valued by the local community (EWNHS, 1996).

Carex monostachya, *Carex fischeri* and *Kniphofia foliosa* of the family Asphodelaceae are among other common plant species found in the area (Endalkachew Teshome *et al.,* 2020).

3.1.4. Fauna

The Guassa area is rich in biodiversity and it consists of abundant and high diversity of endemic and highland range restricted bird species. The occurrence of several endemic species attracts visitors to this area. According to a study by Yihenew Aynalem and Bezawork Afework (2018) a total of 86 bird species from 35 families were identified from the area. The site is a known location for substantial numbers of Spot breasted Plover (*Vanellus melanocephalus*), Rouget's Rail (*Rougetius rougetii*) and Abyssinian Longclaw (*Macronyx flavicollis*). Important Bird Area Survey team recorded 136 Spot- breasted Plover foraging on the Afro- montane grasslands of Guassa. There is also a breeding record of Blue-winged Goose (*Cyanochen cyanoptera*). The site hosts a minimum of 26 Highland biome species, of which 4, Spot-breasted Plover, Abyssinian

Longclaw, Abyssinian Catbird (*Parophasma galinieri*) and Black-headed Siskin (*Spinus notatus*), are Ethiopian endemic (EWNHS: 1996).

The area harbors nine of the endemic mammals of Ethiopia, including the Ethiopian wolf (*Canis simensis*), the Gelada Baboon (*Theropithecus gelada*) and the Abyssinian Highland hare (*Lepus starcki*). With six packs of wolves, the area is a key and the last refuges in Northern Shewa for the Ethiopian Wolf. Other mammals seen in the area are Grey Duiker (*Sylvicapra grimmia*), Klipspringer (*Oreotragus oreotragus*), Leopard (*Panthera pardus*), Abyssinian Hare (*Lepus habessinicus*) and various rodent species (EWNHS, 1996).

3.2. Materials

Materials that were used during the study were Global Positioning System (GPS), binoculars, stopwatch, data sheet, bird guide book (Redman *et al*., 2011), notebook, camera and other stationary materials relevant to record data during the study.

3.3. Methods

3.3.1. Preliminary survey

Ecological survey of birds in and around MGCCA was carried out to gather relevant information. In this survey, an overall view of birds specifically to Wattled ibis of the area was conducted. Information about the distribution, foraging habit and activities of Wattled ibis was collected from local people living around the study area. The topographical features as well as vegetation cover of the area was assessed.

3.3.2. Data collection

Based on the information collected and site selected during the preliminary survey, field data were gathered. Data were collected during the wet (August) and dry (January) seasons in 2020/2021. Data were collected for a total of 20 days, 10 days during the wet season and 10 days during the dry season. Three sites were selected where the species is highly abundant (Fig. 2). Data were collected early in the morning (7:00 am) to late afternoon (6:00 pm). Binoculars as well as naked eye observation were used. Field data sheet was used to record the activity patterns and feeding habit of the species.

3.3.2.1. Activity pattern

The activity pattern of Wattled ibis was recorded for a total of 84 hours using scan sampling method where each bird's behaviour was recorded at predetermined time for certain period (Kabir *et al*., 2013). In this study five minute scan sample was taken in an interval of ten minutes. The activities of all visible individuals were recorded in each scan and the behaviour of each bird during the scan was recorded. These activities were recorded by dividing the day into three time slots; morning 7:00-10:00 hrs, mid-day 12:00-14:00 hrs and late afternoon 16:00-18:00 hrs. The activities were divided into five major categories following Asokan *et al*. (2010):

a. Feeding: capturing prey and swallowing into the buccal chamber.
b. Scanning: scanning surroundings actively.
c. Flying: in flight.
d. Preening: comfort movements including feather shaking, wing flapping, bill cleaning, bill scratching, and body and tail shaking.
e. Resting: dozing with head retracted and eyes closed.
f. Others: activities such as calling, showing agonistic activity, etc.

3.3.2.2. Foraging behaviour

Repeated observations were carried out during the wet and dry seasons to collect data about feeding habits of Wattled ibis. The data was collected in the morning from 8:00-10:00 hrs and late in the afternoon from 16:00-18:00 hrs. The data were recorded using focal sampling method following Sutherland *et al.* (2005). Individual bird was followed from a distance of 5-10m. The bird was observed for 10 seconds before recording any data. A stop watch was used to record the rate of probing per minute for a total of two hours in the morning and late afternoon. However, when the focal bird stopped foraging before 30 seconds the data was discarded. While when the focal bird was lost from sight, another bird was selected as the focal bird.

The abundance of food items in the area was quantified using a 1 meter by 1 meter quadrant (Plate 6). The quadrants were dug at a 20cm depth and food items were counted from each quadrant. A total of 12 quadrants were done in the study area during the wet and dry seasons.

Plate 3: Sampling Quadrant (photo: Faru Hunduma 2021)

3.4. Data analysis

The data were presented in tables and graphs using Microsoft Excel computer program. Further comparison was made on mean rates in activity pattern recorded in the wet and dry seasons using statistical package for social sciences (SPSS) software version 25. A two-way analysis of Variance (ANOVA) was used to compare significance of variation of activity patterns between the three time slots and between hours of the day. To determine whether there was a difference between probing rate and food items consumed in different seasons (wet and dry season) a one-way analysis of variance was used. In all the statistical tests conducted, the level of significance was always set as $p<0.05$.

4. RESULTS

4.1. Activity Patterns

Wattled ibises were observed engaging in different daily activities of feeding, scanning, flying, preening, resting and other activities. During the wet season feeding activity comprised highest percentage (75.5%) followed by preening (6.5%), scanning (6.2%), flying (5.8%), other (4%) and resting (1.8%) comprised the lowest. Similarly, during the dry season feeding activity comprised the highest percentage (79.4%), followed by preening (5.2%), scanning and flying (4.9%), others (4%) and resting (1.4%) (Fig. 3).

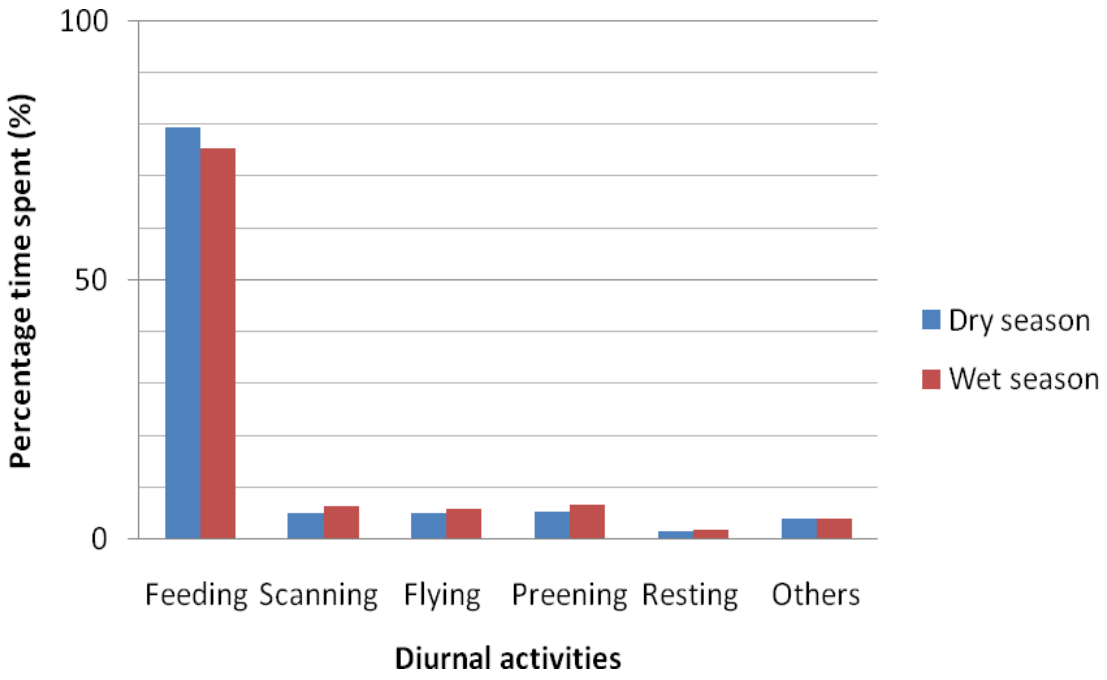


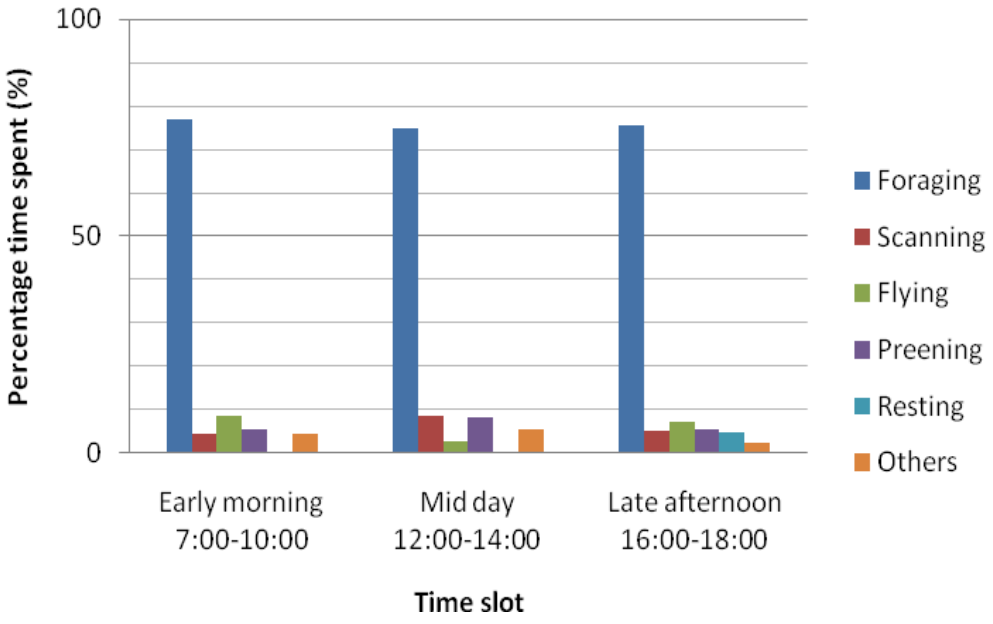
Figure 3: Percentage time spent for different activities in Wattled ibis during the dry and wet seasons

The proportion of time allocated for feeding activity by Wattled ibis varied with season, and it was significant ($F_{1, 29} = 8.176$, $p = 0.008$). (Table 1).

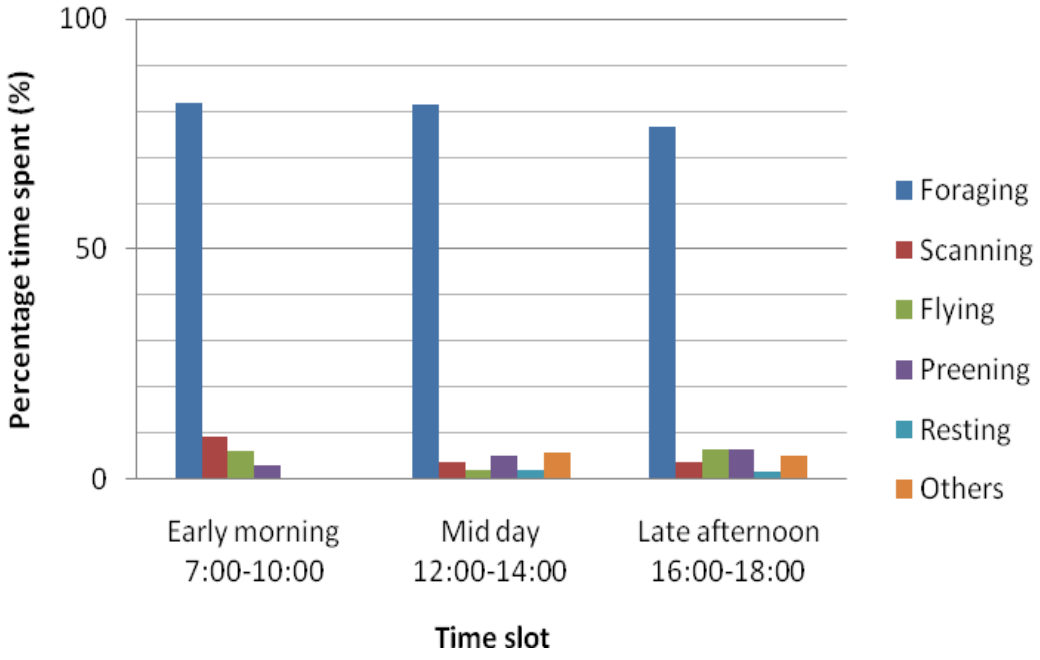
Table 1. Mean proportion of time allocated for different activities of Wattled ibis during wet and dry seasons.

	Proportion of time spent			
Activity	Wet season	Dry season	F	P
Feeding	38.87± 18.593	22.33 ± 12.482	8.176	0.008
Scanning	3.20 ± 3.448	1.40 ±1.549	3.402	0.076
Flying	3.00 ± 2.777	1.40 ± 2.947	2.341	0.137
Preening	3.33 ±3.109	1.47± 1.807	4.041	0.054
Resting	0.93 ± 2.374	0.40 ± 0.632	0.707	0.408
Others	2.13± 2.875	1.13± 2.264	1.120	0.299

The mean proportion of time allocated to different activities varied with the time of the day during the wet and dry seasons (Fig. 4) in Wattled ibs. As compared to other activities feeding was the most pronounced activity in all the three time slots both during the wet and dry seasons. There was no statistically significant difference in the time spent for feeding between the three time slots ($F_{2,5}$=1.39, p=0.42) and seasons ($F_{1,5}$=6.52, p=0.12). However, there was a statistically significant difference in the mean rates for flying with rates being significantly higher in the early morning and late afternoon than in the mid-day during the dry and wet seasons ($F_{2,5}$=26.19, p=0.037). Flying activity was not significantly different between seasons in the three time slots ($F_{1,5}$=4.02, p=0.183). Also, there was no statistically significant difference in the mean rates for scanning ($F_{2,5}$=0.26, p=0.79), preening ($F_{2,5}$=1.01, p=0.49), resting ($F_{2,5}$=1.69, p=0.37), and other activities ($F_{2,5}$=0.79, p=0.56), between early morning, mid-day and late afternoon hours of wet and dry seasons.



a)



b)

Figure 4: Activity patterns of Wattled ibis in three time slots during a) wet and b) dry seasons

The activities of Wattled ibis varied in different hours of the day in the wet (Fig. 5) and dry (Fig. 6) seasons. Feeding was the most pronounced activity than other activities in different hours of the day in both seasons. During the wet season Wattled ibis showed highest rate of feeding between 8:00-9:00 hours than other hours of the day comprising 79.5%. While during the dry season highest rate of feeding was recorded between 16:00-17:00 hours than other hours of the day comprising 86.46%. However there was no statistically significant difference of feeding activity between different hours of the day in both seasons ($F_{6,13}$=152.99 , p=2.71E-06). Flying activity showed statistically significant difference between different hours of the day in both seasons ($F_{6,13}$=10.43 , p=0.0058). Highest rate of flying activity was observed between 8:00-9:00 hours comprising 15.91% in the wet season. While in the dry season flying activity was highest between 17:00-18:00 hours than other hours of the day comprising 12.64%. There was no statistically significant difference in the mean rates for scanning ($F_{6,13}$=1.35, p=0.36), preening ($F_{6,13}$=2.55, p=0.14), resting ($F_{6,13}$=1.43, p=0.34), and other activities ($F_{6,13}$=1.46, p=0.33), between different hours of the wet and dry seasons.

During the wet season highest rate of preening was recorded between 12:00-13:00 hours and highest rate of scanning was recorded between 13:00-14:00 hours. Resting activity was highest between 16:00-17:00 hours and other activities recorded highest rate between 9:00-10:00 hours.

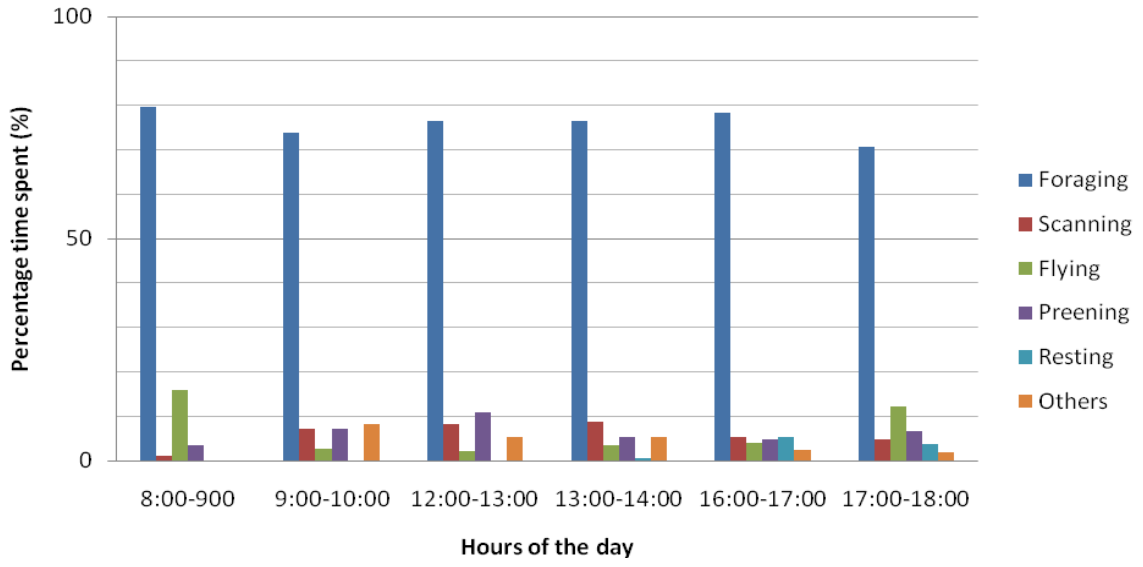


Figure 5: Diurnal activities of Wattled ibis in different hours of the day during the wet season

During the dry season highest rate of preening was recorded between 17:00-18:00 hours and highest rate of scanning was recorded between 9:00-10:00 hours. Resting activity was highest between 12:00-13:00 hours and other activities recorded highest rate between 13:00-14:00 hours.

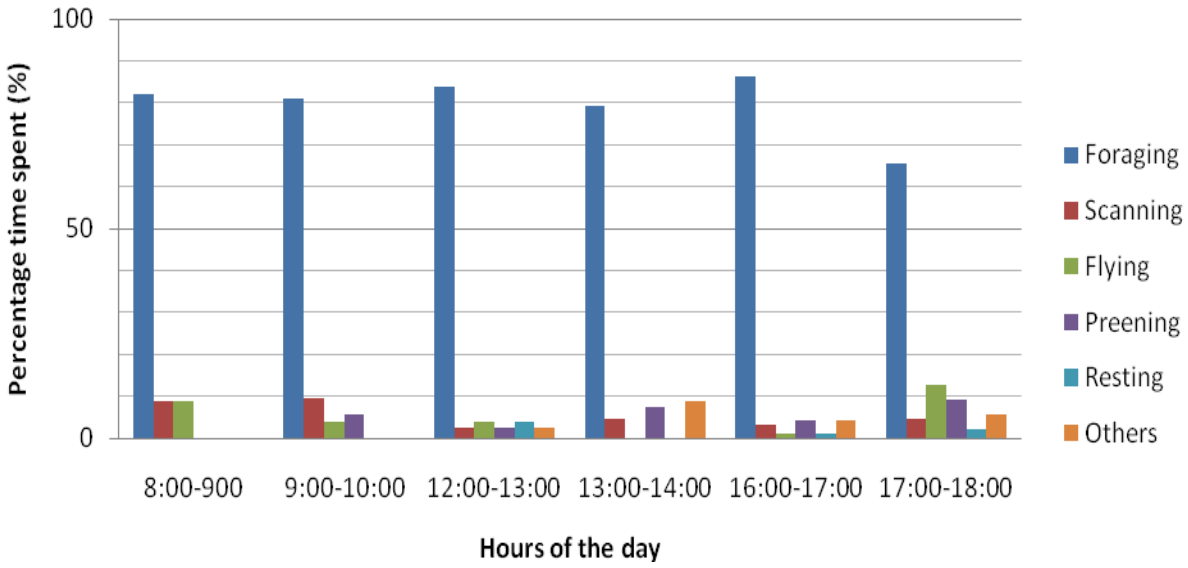


Figure 6: Diurnal activities of Wattled ibis in different hours of the day during the dry season

4.2. Foraging Behaviour

Wattled ibises were observed foraging in different habitats like open grasslands, marshes, farmland and shrublands. Wattled ibises were observed foraging with Blue-winged goose (*Cyanochen cyanoptera*) and Moorland francolin (*Scleroptila psilolaema*).

4.2.1. Food Type

The study showed that the diet of Wattled ibis in percentage frequency consisted of worms (72.3%) and insects (27.7%) during the wet season. Also, during the dry season 71.4% consisted of worms and 28.6% consisted of insects (Fig. 7). There was a statistically significant difference in the type of food consumed by Wattled ibis during both seasons ($F_{1,3}$=2942.4, p=0.012). However, there was no statistically significant difference in the type of food consumed between the wet and dry seasons ($F_{1,3}$=0.0013, p=0.98). During both seasons there was higher abundance of worms than insects. A total of 373.3±38.5 worms and 143.3±26.87 insects were counted in the wet season. On the other hand a total of 66.67±5.47 worms and 26.67±7.79 insects were counted in the dry season from the quadrants.

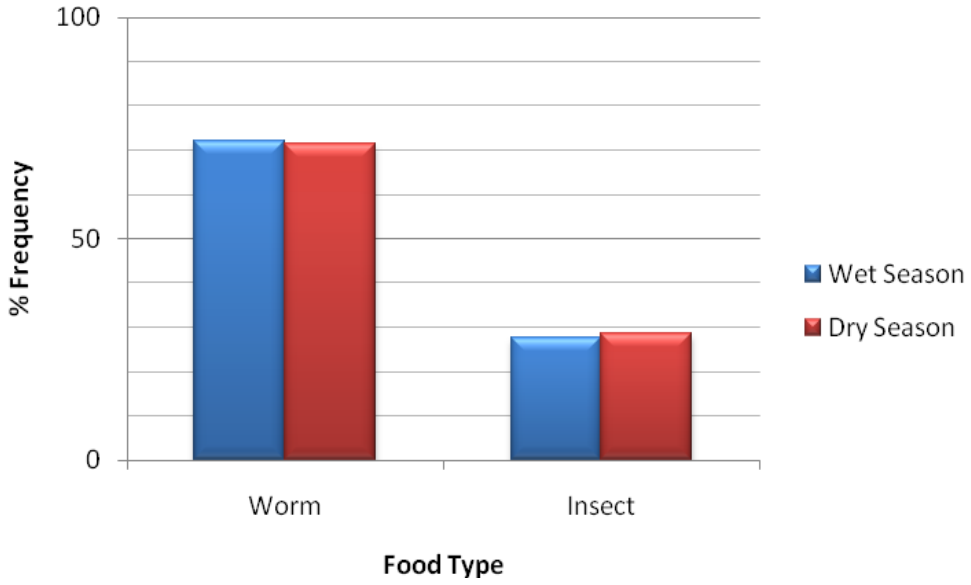


Figure 7: Diet of Wattled ibis during the wet and dry seasons

4.2.2. Probing Rate

Probing was the main foraging strategy of Wattled ibises observed during the study. They also pecked food items on the surface. During foraging, Wattled ibises continuously probed the ground by lowering their head down. A total of 19,510 and 10,242 feeding attempt were recorded in the dry and wet seasons respectively. The average probing rate per minute of Wattled ibis was found to be higher in the dry season (44/minutes) than the wet season (24/minutes) (Fig. 8). There was statistically significant difference in the probing rate between seasons ($F_{1,7}$=55.65, p=0.000299).

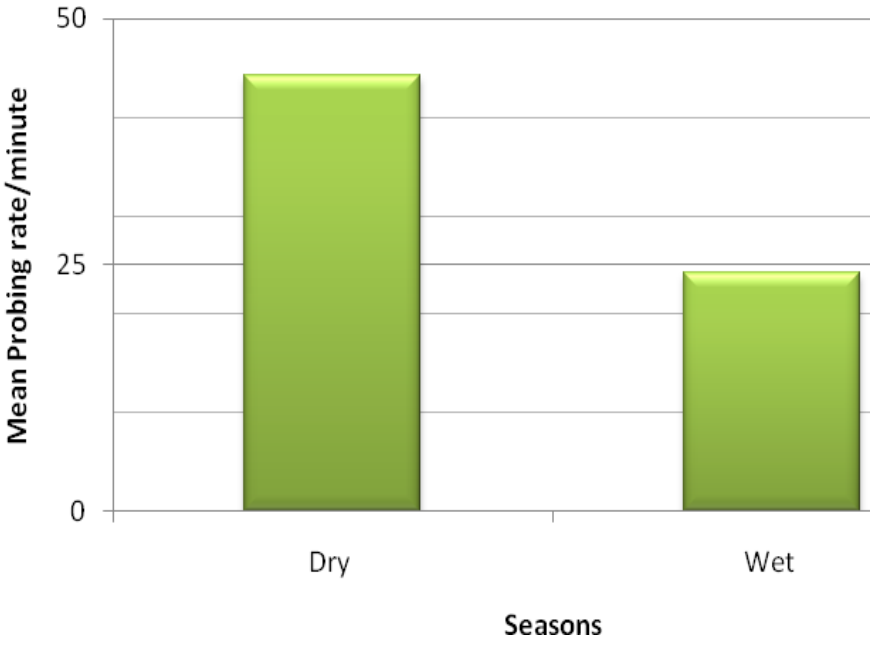


Figure 8: Mean probing/minute of Wattled ibis during the wet and dry seasons

5. DISCUSSION

Wattled ibis exhibited variety of activities in the day time in response to its daily needs. The study showed that feeding was the most frequently observed activity of Wattled ibis in both dry and wet seasons. This is due to the fact that energy requirements are the driving factor in time allocation of animals. Moreover the study indicated that feeding activity is higher in the dry season than the wet season. The wet season is important for many birds as there is ample supply of food, thus the period of feeding is shortened. On the other hand there is scarcity of food items in the dry season, thus birds are required to spend most of their time feeding to fulfill their energy requirements. The dry season was the hardest time to Wattled ibises. They spent additional energy to forcefully pullout grass and spent more time to search prey (Kalkidan Esayas, 2017). In addition, in the dry season the weather condition is more favorable to forage uninterrupted, thus spending more time on foraging (Kidest Ameha and Bezawork Afework, 2018).

Feeding was the most pronounced activity of Wattled ibis in the morning, mid-day and late afternoon in both seasons. This might be related to the abundance of food in the area. As the data showed there is high abundance of worms in the area than insects. According to Okolie *et al*. (2015) it was described that insect diet is high in nutritional value and it is rich in easily digestible protein and fat. As a result in order to fulfill their nutritional requirements Wattled ibises spent most of their day time engaged in feeding activity.

Preening was the second main diurnal activity of Wattled ibis and it was higher during the wet season than the dry season. This is due to the need of preening after a heavy shower and usually preening increase after swimming (Kabir *et al*., 2013). Time spent for scanning was the third major diurnal activity for Wattled ibis and it was more pronounced during the wet season than the dry season. Similar result was obtained by Kalkidan Esayas (2017). Wattled ibises spent less time on feeding in the wet season as compared to the dry season so this might have forced them to devote more time on scanning in the wet season.

The flying activity of Wattled ibis followed a bimodal diurnal pattern with its peak in the early morning (8:00-9:00) and late afternoon (17:00-18:00). This may be due to the fact that birds are engaged in movement in the morning and late afternoon. Wattled ibises began their activity early

in the morning with long distance flight to their feeding sites. While the late afternoon movement were characterized by the return of Wattled ibis to roost sites. In addition flying activity was performed in response to different anthropogenic disturbances. Anthropogenic disturbance and inter-and intra-specific competition are among the primary causes that initiate flight (Ali *et al.*, 2010).

Resting occupied a small portion of the time budget of Wattled ibises and this may be due to the fact that the area was mainly used as a feeding ground of Wattled ibises. Thus, as feeding activity of Wattled ibises took the highest portion of their daily time budget less time was spent on resting.

The main prey items of Wattled ibis were identified to be worms and insects. Indeed, similar result was obtained by Kalkidan Esayas (2017). This showed that Wattled ibises consume small range of food items. The foraging technique Wattled ibises were observed using might have limited food type consumed by Wattled ibis. According to Murray (2009) species those hunt by sight and exhibit a wide variety of foraging techniques are more likely to obtain a broad range of food items in a wide range of habitats. Wattled ibis are known to be non-visual foragers accordingly the diet range of Wattled ibis is restricted. In another study by Hilton *et al.* (1999) it was suggested that digestion efficiency also determines range of food type consumed by a species. Accordingly, a species with a strategy of rapid but inefficient digestion may be restricted to high quality food types, while species with a strategy of slow but efficient digestive strategy are able to exploit a wider range of food types.

Wattled ibises use probing as a foraging technique to obtain food. In a study by Kalkidan Esayas (2017) it was described that when feeding ibises continuously probe the mud lowering their head down to filter out prey materials. Similarly a study on the American white ibis by Kushlan (1979) supported this idea that while feeding in wetlands, the basic feeding technique by ibises were probing. Probing was observed to be the most profitable foraging technique. Moreover, Species with tactile hunting techniques have great chance of foraging success, since much of their time budget is concentrated on foraging. In addition Species with tactile feeding usually forage in intraspecies or interspecies flocks. Thus, foraging in groups reduces the risk of predation and, as a result reduces the cost of vigilance (Norazlimi and Ramli, 2015).

During both seasons, there was higher abundance of worms than insects. High frequency of worms could be due to the high moisture content of the area especially during the wet season which is favorable condition for worm growth. As described by Ivask *et al.* (2006), worm abundance is highly influenced by soil moisture level than any other factors.

The data showed that the mean probing rate per minute in the dry season was higher than the wet season. This may be related to the less availability of food in the dry season as a result the feeding attempt increases. Spending more time on foraging is important in order to satisfy daily energy expenditures mainly in dry season where there is scarcity of food items (Kidest Ameha and Bezawork Afework, 2018).

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study provided knowledge on activity patterns and foraging behaviour of Wattled ibis, and how it was influenced by factors of seasonality and time of the day. Seasonality, type of habitat, food availability and time of day were identified as key factors that influence the activity patterns and foraging behaviour of the Wattled ibis.

Wattled ibis spent most of the time budget on feeding in both dry and wet seasons. However variability was not observed in the time spent on feeding activity between the three observation periods of the day; early morning, mid-day and late afternoon. Flying activity significantly varied between the three time slots and it was higher in the morning and late afternoon.

Wattled ibis predominantly consume worms and insects. Food abundance and availability are important factors that influence the foraging behaviour of Wattled ibis. Worms are less nutritious than insects but were the most abundant in the area. This implies that Wattled ibises should spend most hours of their day on feeding to satisfy their nutritional requirement.

Wattled ibises showed higher feeding attempt per minute in the dry season where there was scarcity of food. They use probing as their feeding strategy which is a non-visual foraging strategy. Thus they feed on a small range of food items.

6.2. Recommendations

- Since the results of this study relied on data collected from one study area (MGCCA), replication of such a study in other habitats for a longer time period will be important in acquiring large data sets for different populations. Furthermore, future studies for longer periods will be important to get more information about the species and facilitate conservation actions.
- Deeper insight into the foraging behaviour and population status is also important in understanding of the species' current status.
- Conservation of MGCCA is needed in order to maintain the population of Wattled ibises in the Area.
- In the present study, the interaction of Wattled ibis with other species was not examined. Hence, there should be future studies to understand how Wattled ibises interact with other species and how this interaction affects their activity patterns as well as their foraging behaviour.
- In this study, the probing attempt was studied; however broader study is important to understand the foraging success of Wattled ibis. Also, studying feeding rate is important to understand predator prey relationships and to quantify the impact of birds on prey communities.

7. REFERENCES

Alemkere Bezabih, Bakala Gabayo and Tolossa Wakjira (2020). Avifauna diversity and anthropogenic threats of wetlands in South-Western Ethiopia. *African Journal of Ecology* **00**:1–12.

Ali, A. M. S. and Asokan, S. (2015). Diurnal activity patterns of the small Bee-eater (*Merops orientalis*) in Southern India. *Tropical Life Sciences Research* **26**(1): 9–20.

Ali, A.M.S., Asokan, S. and Nithiyanandam, G.T. (2010). Habitat related density and activity patterns of the White-breasted kingfisher (*Halcyon smyrnensis)* in Cauvery Delta, Southern India. *Podoces* **5**:54-62.

Altman, J. (1974). Observational study of behaviour: Sampling method. *Behaviour* **43**: 227-269.

Asokan, S., Ali, A.M.S., Manikannan, R. and Nithiyanandam, G.T. (2010). Population densities and diurnal activity pattern of the Indian Roller (*Coracias benghalensis)* in Nagapattinam District, Tamil Nadu, India. *Journal of Threatened Taxa* **2**: 1185-1191.

Barbosa, A. and Moreno, E. (1999). Evolution of foraging strategies in shore birds: An eco-morphological approach. *Auk **116***: 712-725.

Beintema, A. and Vessem, J.V. (1998). Strategies for conserving migratory waterbirds proceedings of workshop of the 2nd international conference on wetlands and development held in Dakar, Senegal. Wetlands International Publication, Senegal.70pp.

Bellanthudawa, B. K. A., Nawalage, N. M. S. K., Subanky, P. A. B. G., Panagoda, H. W. G. A. S., Weerasinghe, L. K. D. N., Tharaka, H. M. A. K., Handapangoda, H. K. A. D. and Silva, D. M. S. N. (2019). Composition and diversity variation of avifauna, along different vegetative habitat types in a human modified area, University of Kelaniya, Sri Lanka. *International Journal of Zoology* **19**: 16pp.

BirdLife International (2021). Country profile: Ethiopia. Available from http://www.birdlife.org/datazone/country/ethiopia. Checked: 2021-08-26.

BirdLife International (2021). Species factsheet: *Bostrychia carunculata*. Downloaded from http://www.birdlife.org on 25/08/2021.

Brown, L.H., Urban, E. K. and Newman, K. (1982). The Birds of Africa. Academic Press, London.

Burger, J. (1978). Competition between Cattle Egret and native North American Herons, egrets and ibises. *Condor* **80**: 15-23.

Burger, J. and Miller, L.M. (1977). Colony and nest site selection in White faced and Glossy Ibises. *Auk* **94**: 664-676.

Emily, K. (1974). Breeding of Sacred ibis (*Threskiornis aethiopica*) at lake Shala, Ethiopia. *The Ibis* **116**(3): 264-277.

Endalkachew Teshome, Fikadu Shita and Firdyiwok Abebe (2020). Current community based ecotourism practices in Menz Guassa Cmmunity Conservation Area, Ethiopia. *Geo Journal.*

Ernst, S. (1969). The Riddle of the so-called "BENIN IBIS" and the artificial Wattled birds. *Journal of African Ornithology* **40**(1): 15-19.

Ethiopian Biodiversity Institute (EBI) (2014). Ethiopia's Fifth National Report to the Convention on Biological Diversity. 72pp.

Ethiopian Wildlife and Natural History Society (EWNHS) (1996). *Important Bird Areas of Ethiopia*: A First Inventory. Ethiopian Wildlife and Natural History Society, Addis Ababa, 300 pp.

Frey, S., Fisher, J.T., Burton, A.C. and Vole, J.P. (2017). Investigating animal activity patterns and temporal niche partitioning using camera-trap data: Challenges and opportunities. Zoological Society of London.10pp.

Gary, H.R. (1990). Habitat specialization and foraging behaviour by birds of Amazonian river island in Northern Peru. *Journal of Ornithological Society* **92**: 427- 443.

Hancock, J.A., Kushlan, J.A. and Kahl, M.P. (1992). Storks, ibises and spoonbills of the world. Academic Press, London. 517pp.

Hilton, G.M., Houston, D.C., Barton, N.W.H., Furness, R.W. and Ruxton, G.D. (1999). Ecological constraints on digestive physiology in carnivorous and piscivorous birds. *Journal of Experimental Zoology* **283**: 365-376.

Hiwot Hibste (2007). Species composition, abundance and activity pattern of birds in Addis Ababa Abattoirs Enterprise area. *Ethiopian Journal of Biological Sciences* **6**(2).

Hughes, J. (2006). Preliminary survey of wattled ibis (*Bostrychia carnuculata*) in Bale Mountains National Park, Ethiopia, with notes on abundance, habitat and threats. *Bulletin of the African Bird club*. **13**: 157-161.

Institution of Biodiversity Conservation (IBC) (2005). National biodiversity strategy and action plan. 103pp.

Ivask, M., Kuu, A., Truu, M. and Truu, J. (2006). The effect of soil type and soil moisture on earthworm communities. Research Gate. 11pp.

Jaime, A.C., James, F.G. and Leopoldo, M.C. (2010). Functional response models to estimate feeding rates of wading birds. *Waterbirds* **33**(1): 33-40.

Kabir, M.M., Sajeda, B. and Hasan, M.K. (2013). Activity pattern of White-Breasted Waterhen at Jahangirnagur university campus, Bangladesh. *Bangladesh Journal of Zoology* **41**(2): 189-198.

Kalkidan Esayas (2017). Species diversity, the ecology of Wattled ibis (*Bostrychia carunculata*) and land use/cover change of Chelekleka Lake, Bishoftu. PhD thesis, Addis Ababa University, Ethiopia.

Kidest Ameha and Bezawork Afework (2018). Diurnal activity patterns and feeding behaviour of African Jacana (*Actophilornis africanus*) in lake Hawassa, Ethiopia. *Ethiopian Journal of Science* **41**(2): 53-60.

Kopij, G. (1997a). Breeding ecology of the African Spoonbill (*Platalea alba)* in the Free State, South Africa. *Ostrich* **68**: 77-79.

Kopij, G. (1997b). Timing of colony occupation, clutch size and breeding success in the Cattle Egret (*Bubulcus ibis)* related to nest location in a South African heronry. *Acta Ornithologica* **32**:169- I 74.

Kopij, G. (1999). Breeding ecology of the Sacred Ibis (*Threskiornis aethiopicus)* in the Free State, South Africa. *African Journal of Wildlife Research* **29**(1): 25-30.

Kopij, G., Kok, O. B. and Roos, Z. R. (1996). Food of Sacred Ibis (*Threskiornis aethiopicus)* nestilings in the Free State province. South Africa. *Ostrich* **67**: 138-143.

Kushlan, J. A. (1979). Feeding ecology and prey selection in the White ibis. *The Condor* **8**(4): 376-389.

Kushlan, J.A. (1976). Site selection for nesting colonies by the American White Ibis (*Eudocimus albus*) in Florida. *Ibis* **118**: 590-593.

Kushlan, J.A. and Kahl, M. P. (1993). Colonial waterbirds. *Waterbird Society*. **16**(1): 104-106.

Luis, S. (2020a). Notes on nesting site of the wattled ibis (*Bostrychia carunculata*) in the central uplands of Ethiopia. *Short Communication* **40**(2): 76-79.

Luis, S. (2020b). Is plastic debris a silent threat to African endemic birds? The case of Wattled ibis (*Bostrychia carunculata)*. *The Bulletin of the African Bird Club Bull* **27**(2): 280-282.

Miller, L. M. and Burger, J. (1978). Factors aflecting nesting success of the Glossy Ibis. *Auk* **95**: 353-361.

Misganaw Mola, Dessalegn Ejigu and Yibelu Yitayih (2021). Species composition, relative abundance, and habitat association of avifauna in Zegie Peninsula Forest Patches and associated wetlands, Bahir Dar, Ethiopia. *International Journal of Zoology* **21**: 1-12.

Murray, N.J. (2009). Foraging behaviour and success of Australian White ibis (*Threskiornis molucca*) in an urban environmrnt. *Notornis* **56**: 201-205.

Newton, I. and Green, R.E. (2005). Bird Ecology and Conservation. A hand book of techniques. Oxford University Press, Oxford.

Norazlimi, N. A. and Ramli, R. (2015). The Relationships between morphological characteristics and foraging behaviour in four selected species of shorebirds and water birds utilizing tropical mudflats. *The Scientific World Journal* **15**: 1-7.

Okolie, M., Turshak, L. and Mwansat, G. (2015). Insect as important delicacy for birds: expanding our knowledge of insect food ecology of birds in the tropics. *Ecology and Safety* **9**: 434-441.

Redman, N., Stevenson, T. and Fanshawe, J. (2011). Birds of the Horn of Africa: Ethiopia, Eritrea, Djibouti, Somali and Socotra. Helmen Field Guide. Princeton University Press, 512pp.

Ronnie, R.A., Jaime, E.J. and Ricardo, R. (2015). Daily patterns of activity of passerine birds in a Magellanic Sub-Antarctic forest at Omara Park (55°), Cape Horn Biosphere Reserve, Chile. *Polar Biology* **38**: 401-411.

Solomon Ayele and Demel Teketay (2017). Contribution of the Guassa Community Eco-Lodge to the conservation of wild mammals, birds and woody plants in Menz-Gera Midir District, North Shewa Administrative Zone, Ethiopia. *International Journal of Avian and Wildlife Biology* **2**(4): 1-11.

Tariku Mekonnen and Abebayehu Aticho (2011). The driving force of Boye wetland degradation and its bird species composition in Jimma, South-Western Ethiopia. *Journal of Ecology and the Natural Environment* **3**(11): 365-369.

Urban, E. K. (1974). Breeding of Sacred Ibis (*Threskiornis aethiopica)* at Lake Shala, Ethiopia. *Ibis* **116**: 263-277.

USAID (United States Agency International Development) (2008). Ethiopian Biodiversity and Tropical Forests 118/119 Assessment. USAID. 81pp.

Vivero, P. J. L. (2001). A Guide to Endemic Birds of Ethiopia and Eritrea. Shama Books, Addis Ababa, Ethiopia. 46pp.

Weldemariam Tesfahunegny (2016). A catalogue for endemic birds of Ethiopia. *The Journal of Zoology Studies* **3**(4): 1-25.

Yihenew Aynalem and Bezawork Afework (2018). Diversity, distribution and habitat association of birds in Menze- Guassa Community Conservation Area, Central Ethiopia. *International Journal of Biodiversity and Conservation* **10**(9): 372-379.

Yousaf, M.A., Noreen, M., Maqbool, M.F., Irfan. A and Ahmad, I. M. (2020). Foraging behaviour of birds at morning and evening times: A preliminary study. *BioScience* **2**(1): 28–39.

Zelealem Tefera, Coulson, T., Zubiri, C. S., and Wiliams, N. L. (2005). Behaviour and ecology of the Ethiopian Wolf in a human-dominated landscape-outside protected areas. *Journal of Animal Conservation* **8:** 113-121.

Ziyad Jemal, Zerihun Girma and Girma Mengesha (2020). Bird diversity in Nensebo Moist Afromontane Forest Fragment, South Eastern Ethiopia. *The Open Ornithology Journal* **13**: 1-9.

APPENDICES

a) 

b) 

c) 

d) 

Appendex 1: Foraging habitats of Wattled ibis a) Marsh b) Shrubland c) Open grassland d) Farmland (Photo: Faru Hunduma 2020/ 2021)

a) 

b) 

Appendex 2: Sample food items collected a) worms b) insect (Photo: Faru Hunduma 2020/2021)

Appendex 3: Wattled ibis foraging in the grassland (Faru Hunduma 2020)