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COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES
DEPARTMENT OF ZOOLOGICAL SCIENCES



**Activity patterns and foraging habits of sacred ibis (*Threskiorinis aethiopicus*
Latham 1790) in Chelekeleka wetland, Bishoftu, Ethiopia**

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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Abstract

The African Sacred ibis (*Threskiornis aethiopicus* Latham, 1790) is one of the 32 species of the family Threskiornitidae, 11 of which are found in Africa. It is the most widespread and most common of this family in Africa. A study on activity patterns and feeding behavior of Sacred ibis (*Threskiornis aethiopicus* Latham 1790) was carried out in Chelekeleka wetland. Data on Sacred ibis diurnal activity patterns and foraging behavior were gathered through repeated observations followed scan sampling and focal sampling methods. Diurnal Activity patterns such as feeding, scanning, flying, preening, resting and other activities were recorded during both wet and dry seasons. Foraging habits of the birds were also recorded at the time when the birds were actively feeding. The results showed that Sacred ibises spent much of their time in feeding (39.8%) followed by resting (33.9%) and preening (16.9%) during the dry season. On the other hand, during the wet season, resting activity was the highest (36.5%) followed by feeding (31.4%) and preening (24.2%). The percentage time spent for feeding activity by Sacred ibis was significantly different between wet and dry seasons ($p < 0.043$). However, the other activities showed no significant difference between wet and dry seasons. Among the three time slots, feeding was the most prominent activity in the morning hours during both dry (69.07%) and wet (59.34%) seasons. There was a statistically significant difference in the time spent for feeding among the three time slots during both seasons ($p < 0.05$). Sacred ibis spent more time resting during mid-day and late afternoon hours, making it their second most important activity. For foraging, Sacred ibises used muddy and marsh areas during both wet and dry seasons. The main food items of Sacred ibis during the study period were different insects and worms during both seasons. Sacred ibises mainly obtain their food by probing. Probing is inserting the bill into the sediment, allowing the capture of invertebrates that live below the sediment surface. A higher probing rate per minute was recorded during the dry season (5.8 times/ minute) than the wet season (4.9 times/ minute). However, the probing rate did not show a significant difference between the two seasons. Sacred ibis actively forage in the marsh and flat muddy habitat both during the wet and dry seasons. They feed highly during the morning hours resting during mid-day and late afternoon. . Chelekelaka wetland is one of the most highly disturbed ecosystems due to several anthropogenic activities. However, Sacred ibis are found throughout the year in this wetland despite such high disturbances. Further studies are required on their adaptation strategies

in such disturbed habitat and conservation efforts are also required to protect this wetland from further threat in order to protect Sacred ibis and other bird species in the area.

Key words: Activity patterns, feeding behavior, Sacred ibis, Chelekelaka, Ethiopia

1. INTRODUCTION

1.1 Background of the study

Ethiopia has approximately 862 bird species, 17 of which are endemic and 19 of which are globally threatened, making it one of Africa's richest and most important ornithological location (Bird Life International, 2021). The higher bird diversity is due to the region's different climatic zones, geography, and habitats. Ethiopian birds can be found in a variety of lush and green woods, woodlands, moist and arid savannah, lakes, mountainous terrain, and wetlands. In Ethiopia, there are 76 Important Bird Areas (IBAs), 30 of which (41%) are wetlands, with the remaining representing varied ecosystems, indicating the importance of wetlands as bird habitats (EWNHS,1996).

Ethiopia has different types of wetlands which provide tremendous socioeconomic and environmental values. These wetlands are important in attracting tourists and giving ground for cultural ceremonies (Gebreslassie Hagose *et al.*, 2014). In addition, these wetlands are important in supporting different bird species. For example, about 204 which is around 25% of Ethiopian birds are wetland dependent (EWNHS, 1996).

Birds are taken as good indicators of biodiversity and monitors of environmental changes, like the level of contamination and environmental impacts. Although defined by its avian fauna, the conservation of important bird areas would ensure the survival of a correspondingly large number of other taxa (Kalkidan Esayas, 2017). Wetland specialists and generalists are the two types of water birds. Specialists are wetlands' nesting, feeding, and roosting birds including those like ducks, gulls, herons, waders, crakes, the Black-crowned crane, and other birds can be found in the area. Generalists are those who specialize in a wide range of habitats. Birds that are commonly seen in wetlands but can also be seen in other habitats include Ibis, herons, some weavers, warblers, plovers, and other birds. Cranes, for example, are classified as terrestrial birds yet only breed in wetlands particularly found to seasonal grass swamps (Mengistu Wondaferash 2003).

The African Sacred ibis (*Threskiorinis aethiopicus* Latham, 1790) is one of the 32 species of the family Threskiornitidea, 11 of which are found in Africa (del Hoyo *et al.*, 1992; Hancock *et al.*, 1992). It is the most widespread and most common of this family in Africa (Brown *et al.*, 1982).

Despite its proximity to humans and high abundance in cities, knowledge of the African Sacred ibis or any of the other 31 ibis species (Threskiornithinae) that occur around the world is inadequate (Meseret Chane and Balakrishnan, 2016). Many ibis species are endangered, critically endangered or have become locally extinct due to habitat destruction and hunting (Hancock *et al.*, 1992).

Chelekelaka wetland is one of the most highly disturbed ecosystems due to several anthropogenic activities. However, Sacred ibis are found throughout the year in this wetland despite such high disturbances. This type of studies are required on their adaptation strategies in such disturbed habitat and conservation efforts are also required to protect Sacred ibis and other bird species in the area.

To conserve biodiversity of wetlands, knowledge on the behavioral ecology of different species is important. In this regard, no study has been conducted on the ecology of Sacred ibis and the present study aimed at investigating the feeding behavior, activity patterns and food handling technique of the African Sacred ibis (*Threskiornis aethiopicus*) in Chelekelaka wetland, Bishoftu, Ethiopia.

1.2 Objectives

1.2.1 General Objective

The general objective of this research was to study the diurnal activity patterns and foraging habits of Sacred ibis in Chelekeleka wetland, Bishoftu town, Ethiopia.

1.2.2 Specific Objectives

The specific objectives of this research were

- ❖ To identify the diurnal activity patterns of Sacred ibis during wet and dry seasons in Chelekelaka wetland
- ❖ To examine the food preference of Sacred ibis in Chelekelaka wetland
- ❖ To assess the food handling technique of Sacred ibis in Chelekelaka wetland

1.3. Research Questions

1. Was there any pattern in the diurnal activities of Sacred ibis?
2. Was there any pattern in the activities and foraging habits of Sacred ibis related to time of the day?
3. How did Sacred ibis handle food items?
4. Did the probing rate of Sacred ibis vary depending on seasons?
5. Did food preference of Sacred ibis vary with season?

1.4. Significance of the study

This research was to develop knowledge and understanding of the diurnal activity patterns and foraging habit of Sacred ibis. Additionally, it showed the effect of season and time on the activity patterns and habit of the bird.

2. LITERATURE REVIEW

2.1. Sacred ibis physical characteristics

Sacred ibis (*Threskiornis aethiopicus*) is a member of ibis and spoonbill family (Threskiornithidae) (Plate 1). These families of birds are wading birds that use their long, downward-curving bills to probe through mud or grass in search of invertebrates and other prey (Steve and Monica, 2009). Sacred ibises are widely distributed in both sub-Saharan Africa and southeast Iraq. Sacred ibis measures 65 to 75 cm in length, 112 to 124 cm in wingspan, and weighs about 1500 g (Maillard *et al.*, 2020). Sacred ibises are primarily white in color, with gray-black feather tips on their wings' trailing edges. On their rumps, they have very distinctive long, black feathers or plumes. The feathers on the sides of their chests and the outer wings (near the edge when folded) may have a yellowish (or reddish) tint during the breeding season, and the lower legs may have a reddish-copper tint. Bare patches of scarlet-red skin may also be seen under their wings. Young Sacred ibises have black and white feathers covering their heads and necks, giving them a mottled appearance. As the birds get older, these feathers fall off. Adults have gray-black, featherless heads and necks, as well as long, curved bills, legs, and feet. The Sacred ibis is a quiet bird with no distinguishing calls (Millard *et al.*, 2020).



Plate1: Adult Sacred ibis (*Threskiornis aethiopicus*) in Chelekelaka wetland (Photo by Hilina Sisay 2021)

Males are slightly larger than females, but there is no seasonal variation or sexual dimorphism. The necks and heads of juveniles are streaked with black and white and have feathers. They have more black on their outer primaries and primary coverts and greenish-brown scapular feathers. Dark streaks are visible on the under wing coverts. Having brown corners, the tail is white (Cramp and Simmons, 1977).

2.2. Taxonomy

The Sacred ibis (*Threskiornis aethiopicus*) is one of 32 species of the family Threskiornitidae, 11 of which occur in Africa. It belongs to this family and is the most prevalent and widespread member on this continent (Kopij, 1999). It forms a super species complex with the black-headed ibis and the Australian white ibis, and the three species are thought to be conspecific by some ornithologists because of their close kinship. They frequently cross breed with other ibises in mixed flocks. The Sacred ibis is a common colloquial name for the Australian white ibis (Clergeau and Philippe, 2009).

2.3. Distribution and habitat

Sacred ibis are native to sub-Saharan Africa, the Middle East, and Madagascar; historically, they were also found in Egypt, where they are now extinct. Large portions of sub-Saharan Africa are home to the common and widespread African Sacred ibis (*Threskiornis aethiopicus*) (Figure 1). In southern Iraq, a small, isolated population still exists. Early in the 19th century, the species was still reproducing in Egypt's Nile Valley, but it decline within a few decades (Maillard *et al.*, 2020). All African Sacred ibises discovered in the wild outside of the African continent are descendants of captive birds that were unintentionally or knowingly released into the wild. There are still wild populations reproducing outside of their natural range in France, Italy, Taiwan, and the United Arab Emirates (Cramp and Simmons, 1977). Breeding has also taken place in the United States, the Netherlands, and Spain. Currently, without any evidence of breeding, free-flying African Sacred ibises are known to exist in Belgium, Germany, the UK, the Netherlands, Portugal, and Spain (Yesou *et al.*, 2017). Southeast Iraq and Sub-Saharan Africa are the breeding grounds for the Sacred ibis. With the rainy season, several populations migrate; some South African birds travel 1,500 km to Zambia in the north, while other African birds north of the equator migrate in the opposite direction. The Iraqi population typically relocates to

southwestern Iran, but roving vagrants have been observed as far north as the Caspian coasts of Kazakhstan and Russia and as far south as Oman (rare, but regular) before 1945 (Maillard *et al.*, 2020)

Birds choose their habitats based on the physiognomy or vegetation structure of the area. Predation, intraspecific and interspecific resource competition, parasites, diseases, habitat availability, and weather can all have a direct or indirect impact on avian populations. Depending on the geographic region, dietary preferences, and bird migration patterns, these factors may have varying degrees of influence (Meseret Chane and M. Balakrishnan, 2016). The African Sacred ibis can live in a variety of mostly wet habitats, such as mud flats, meadows, inland marshes, and freshwater wetlands. The species also lives in mangroves, offshore islands, intertidal zones, and coastal lagoons.



Figure1: Distribution map of Sacred ibis (Source: BirdLife International, 2023)

2.4. Social behavior

Sacred ibis are social birds that forage, moves in large flocks, and spends its time together. They typically occur in flocks of two to twenty individuals, though they have been observed in larger flocks of up to 300 birds. Like most wading birds, ibises fly in a "V" formation, which aids trailing birds in overcoming wind resistance. When the worn-out front ibis falls to the rear, an alternative ibis takes its place at the front of the formation (Maillard *et al.*, 2020).

Large colonies of Sacred ibises are also formed when they are nesting. They congregate as well for roosting and foraging. They may migrate seasonally to foraging and breeding locations and cover a lot of ground while foraging (Cramp and Simmons, 1977). Like many wading birds, Sacred ibises roost in trees at night, often in large groups of hundreds of birds, sometimes with birds of other species (Steve and Monica, 2009).

2.5. Breeding Behavior

Sacred ibises form seasonally monogamous breeding pairs that nest in large nesting colonies (Kopij, 1999). They breed near their foraging and roosting grounds, and may nest individually or build large, communal platforms of sticks that hold as many as 30 nests. Each pair builds a nest of twigs, in which the female lays 2–3 eggs. The eggs hatch in 28–29 days, and the young remain in the colony for an additional 44–48 days; both the male and female care for the eggs and young birds. In the Everglades, Sacred ibises roost and nest on tree islands, often among native species (Steve and Monica, 2009).

During the breeding season large groups of males select a spot to settle and form pairing territories. In these territories males stand with wings held downwards and restricts spread. In the following several days' females arrive in the nesting colony, along with more males. Newly arriving males go to the established territories of settler males and compete for the territory. Fighting males may strike at each other with their bills and make squealing noises. Females choose among males and their pairing territories and pairs are formed. Once the pair is formed, the couple moves to a nearby nesting area selected by the female (Cramp and Simmons, 1997). Fighting behavior may continue in the nesting area between neighboring individuals of either sex. Individuals will stand with wings outstretched and head lowered with bill open towards other individuals. Individuals that are very close to each other may adopt a similar stance, but with bill pointed upwards, nearly touching, while making calls (Charlie, 2008).

During pair formation the female approaches the male and, if she is not chased away, they face one another and bow with necks outstretched forward and towards the ground. After this they assume a standing posture and intertwine their necks and bills. This may be followed by more bowing or extensive self-preening (Charlie, 2008). The pair then establishes a nest territory where copulation occurs. During copulation, females crouch, so males may straddle them; the

male may grab the female's bill and shake it side to side. After copulation the pair again assumes a standing position and extensively preens themselves at the nest site (Cramp and Simmons, 1977).

2.6. Foraging Behavior

Birds' diets and the associated bill morphology can be used to identify their foraging behavior (Frank, 2007). Some of the differences among birds are seen in their bill adaptations for feeding. Certain aspects of gross bill morphology and micro-anatomy are known to be adaptive to specific modes of foraging. Some of the foraging behaviors of bird are probing, jabbing, and fossicking. Sacred ibis consists of long and curved bill modified for probing. Probing is inserting the bill into the sediment, allowing the capture of invertebrates that live below the sediment surface. Probing is observed more frequently in species with long and curved bills than in species with short and straight bills (Barbosa and Moreno, 1999). A probing curved bill is able to inspect a greater volume of sediment than a straight bill of equal length (Ferns and Siman, 1994).probe foraging birds use two tactile techniques direct touch and remote touch to find their prey that is concealed in the soft substrates they feed on. For a long time, it was thought that probing birds primarily used direct touch sometimes in conjunction with other sensory cues to detect prey when it made physical contact with the probing beak (visual, auditory and chemical) (Cullen and Sean ,1994).

The Sacred ibis use "remote-touch" to find prey items buried in dark substrates. In the absence of other sensory cues, they can locate their prey using high frequency substrate vibrations thanks to this sensory ability. A specialized bill-tip organ that has high densities of mechanoreceptors (Herbst corpuscles) embedded in numerous foramina in the beak bones allows for remote touch (Carla, 2021).

The diet of Sacred ibises is diverse and includes a wide variety of prey items. The generalist diet of this species may help it to successfully invade and survive in new areas. Sacred ibises often forage in groups of 2–20 individuals, using their long, curved bills to probe mud or grass for prey or scavenge for scraps in garbage. They will eat virtually anything that moves insects, worms, crayfish, mollusks, other invertebrates, small fish, amphibians, and small rodents. Sacred Ibises can also prey on the eggs and nestlings of other birds, especially seabirds. In addition, in urban

areas they are often found near trash heaps, where they eat a variety of scraps and other refuse (Steve and Monica, 2009).

2.7. Conservation Status

The African Sacred Ibis is one of the species protected by the African-Eurasian Migratory Water bird Agreement (AEWA). Several Ibis species have declined due to habitat destruction, poaching, and insecticide use. The Sacred ibis moves through croplands, assisting egrets and other birds in ridding the area of insect pests. They are extremely valuable to farmers due to their role in crop pest control. However, agricultural pesticide use has put birds in danger in a number of locations. According to IUCN criteria, the species is considered to be of Least Concern because the global population, which is thought to be stable or declining, is estimated to be between 200,000 and 450,000 (Yesou *et al.*, 2017).

3. THE STUDY AREA

Chelekelaka wetland is located about 47 km southeast from Addis Ababa (Figure 2), It supports a large variety of resident and migrant bird species including Sacred ibis. It is an Important Bird Area (IBA), supporting more than 20,000 water birds seasonally (EWNHS, 1996). It is a seasonally inundated pan and attracts large numbers of water birds following the Palaearctic migration during the months from September to February. During this time, migrant birds from northern hemisphere augment resident birds (Kalkidan Esayas, 2017). The size of the wetland varies from year to year depending on the amount of precipitation and floods received from the surrounding highlands. It forms interrupted swampy small areas during the dry season and it completely dries out (March and May) in long dry seasons or drought years (Yeshimebet Mamo, 2006). The annual rain fall of 97.5mm (NMA, 2023).

An important threat to Chelekelaka wetland is habitat destruction and shrinkage. It is intensively cultivated on the fringes by local farmers who grow mainly chick peas and different kinds of vegetables. Various agro-industrial enterprises have land holdings around the wetland as well. These industries use different pesticides and fertilizers during their production processes (Daniel Assefa, 2015).

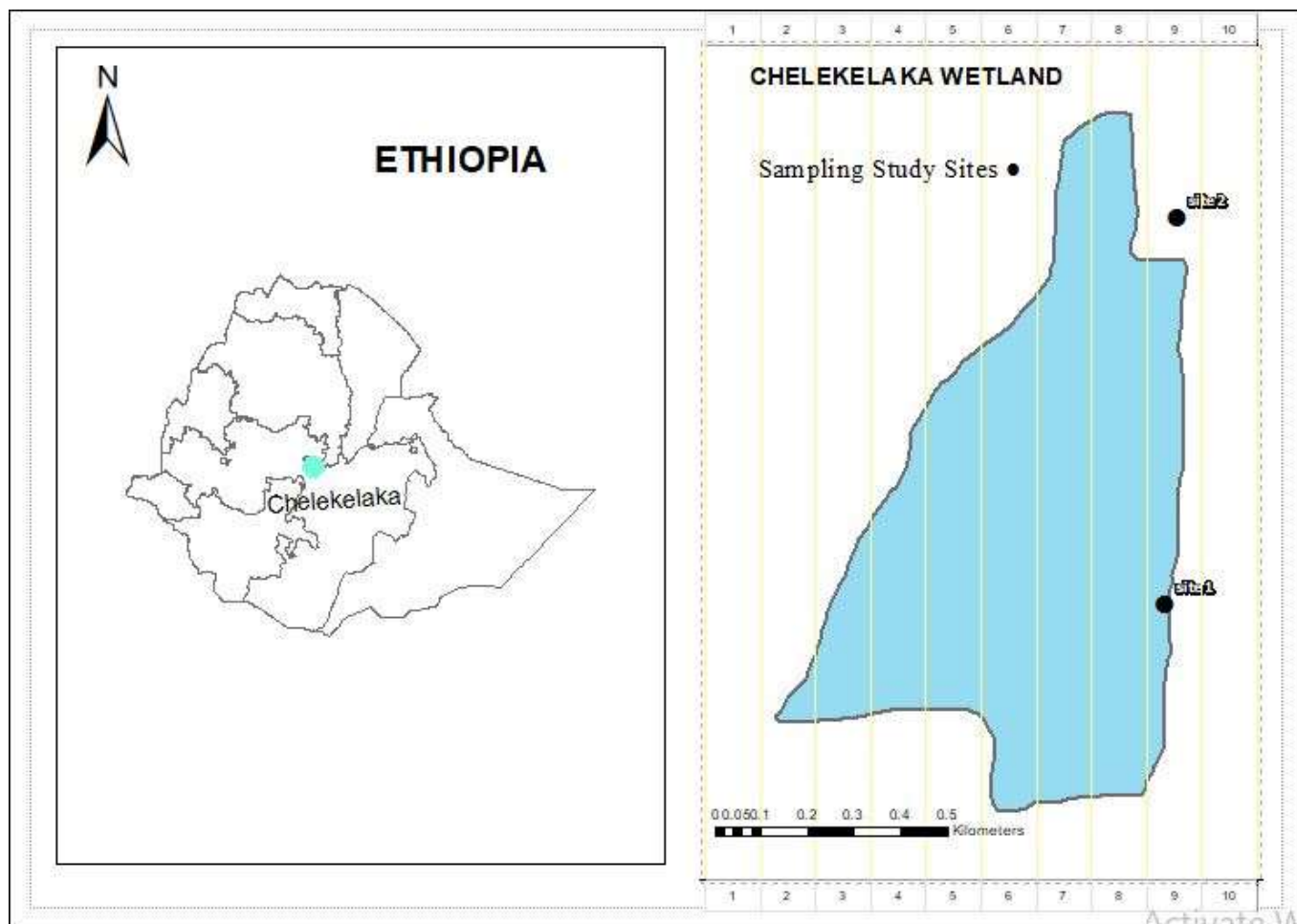


Figure 2. The map of Chelekelaka wetland located near Debrezeit town, Ethiopia.

3.1. Topography

The study area has a rugged topography with rolling terrain, with an average elevation of 1920 meters above sea level. In the study area, luvisols, lepthosols, nithosols, vertisols, and cambisols are the most prevalent soil types (Daniel Assefa, 2015). Its topography is undulating and characterized by flat land on the north and east of the town, locked by several lakes, while the south is dominated by hills (BCP, 2015).

3.2. Flora

The shallowness of the water has resulted in a broad shoreline. The pan encourages the development of wetlands' plant life, which in turn makes the wetlands productive and life-sustaining. Aquatic plant at Chelekeleka Lake include *potamogeton spp.*, *Typha spp.*, *Persicaria spp.* and *Odontelytrum abyssinicu*. There are some remnant natural forests with various tree species around the lake. such as: *Afrocarpus falcatus*, *Prunus africana*, *Albizia guifera*, *cordia africana*, *Aningeria adolfi-friederici* and *Croton macrostachus* occur. Plantation woodlots with exotic tree species such as *Eucalyptus* species, *Gravilea robusta*, and *Cuprunus lustanica* are common (Kalkidan Esayas, 2017).

3.3. Fauna

At Chelekeleka Lake, Avian diversity have been observed 246 species and 62 families belonging to 20 orders including endemic birds such as, the Yellow-fronted Parrot (*Poicephalus flavifrons*) and Blue-winged Goose (*Cyanochen cyanopterus*), Erlager's Lark (*Calandrella erlangeri*), Wattled ibis (*Bostrychia carunculata*), White-winged Cliff Chat (*Thamnolaea semirufa*), Blue-breasted Bee-eater (*Merops variegatus*), Banded Barbet (*Lybius undatus*), Black-billed Barbet (*Lybius guifsobalito*), Black-winged lovebird (*Agapornis taranta*), Black-eared Wheatear (*Oenanthe hispanica*), and White-collared Pigeon (*Columba albitorques*) were observed. (Mebrat *et al.*, 2023). Rare waterfowl and raptors can be found at the Important Bird Area (IBA) of Chelekelaka Lake. Over 20,000 water birds live at the location. Seasonally, over 18,000 common cranes that roost in the shallow waters October through March (Daniel Assefa, 2015).

4. MATERIALS AND METHODS

4.1 Materials

The materials that were used during the study period were Binoculars ,Photographic camera ,stop watch, Note book and pencil ,Bird guide book and global positioning system (GPS) .

4.2. Methods

4.2.1 Preliminary survey

Ecological survey of birds in and around Lake Chelekeleka was carried out to gather relevant information on Sacred ibis in this survey, an overall view of birds specifically to Sacred ibis of the area was conducted.

4.2.2 Data collection

4.2.2.1. Activity patterns

Ecological studies on the activity patterns of Sacred ibis data were collected during both wet and dry seasons. Two sampling sites were selected based on purposing sampling method and Sacred ibis abundance. The activity pattern of Sacred Ibis was recorded using scan sampling method throughout the study period following Altman (1974). During the observation period, a group or an individual bird was followed at a distance of 5-10 m. five minutes scan sampling was taken at intervals of 10 minutes. The activities included feeding, preening, resting, flying and scanning and other activities.

Table 1: Sacred ibis activity in Chelekelaka wetland

Foraging	Defined as looking for food while walking with a lowered head or head down, picking food items, and consuming them.
Resting	A Sacred ibis' resting behavior includes pausing, sleeping, or loafing.
Scanning	Scanning or observing the surroundings by raising its head or extending its neck refers to vigilance or alert behavior of Sacred Ibis
Preening	Preening or cleaning as well as muscle stretching.
Flying	refers to the mode of locomotion or flight
Other activity	Activities such as calling, fighting, are showing agonistic activity.

The activities of all visible individuals were recorded in each scan and the behavior of each bird during the scan was recorded. This activities were recorded by dividing the day into three time slots; morning 7:30-9:30 hrs , mid-day 12:00-14:00 hrs and late afternoon 15:30-17:30hrs.

4.2.2.2. Food preference and probing rate

To collect data on feeding habits of Sacred ibis, repeated observations were made during the wet and dry seasons. Data were collected in the morning from 8:00-10:00 hrs and late in the afternoon from 16:00-18:00 hrs when the majority of the birds were engaged in feeding (Sutherland *et al* .,2000). Data were recorded using focal sampling method following Sutherland *et al* (2005). A single bird was followed from a distance of 5 to 10 meters. Ten seconds were spent watching the bird before any data were gathered. For a total of two hours in the morning and late afternoon, the food items the bird feeds on and the rate of probing per minute was recorded using a stop watch. However, the data were discarded if the focal bird stopped foraging

before the 30 second mark. A different bird was chosen to serve as the focal bird when a bird disappeared from view.

The type of food item in the area where Sacred ibis frequently forage was assessed using a 1 meter square quadrant (Plate 2). Food items were identified from each quadrant after the quadrants were dug to a depth of 25 cm. In the study area, 10 quadrants were done during both the wet and dry seasons.



Plate2: Sampling quadrant in Chelekelaka wetland

4.3. Data analysis

Data were analyzed using a one-way analysis of variance (ANOVA) and Tukey test. Tukey test methods of data analysis were used to compare significance variation of activity patterns among the three different time slots and between hours of the day. One-way analysis was used to determine whether there was a significant difference between probing rate in different seasons (wet and dry season). In all the statistical tests conducted, the level of significance was always set as $p < 0.05$ and the results were presented in table and graphs.

5. RESULTS

5.1. Activity pattern

Sacred ibises were seen engaging in various daily activities of foraging, scanning, flying, preening, resting and other activities (Fig 3). During the dry season (5409), feeding activity constituted the highest percentage 39.8% (2153) followed by resting 33.9% (1837), preening 16.7% (903) and other activities such as fighting and walking which was the least 1.3% (71). During the wet season (3944), resting activity was the highest 36.5% (1442) followed by feeding 31.4% (1240), preening 24.2% (956), and other activity representing the least 0.3% (13).

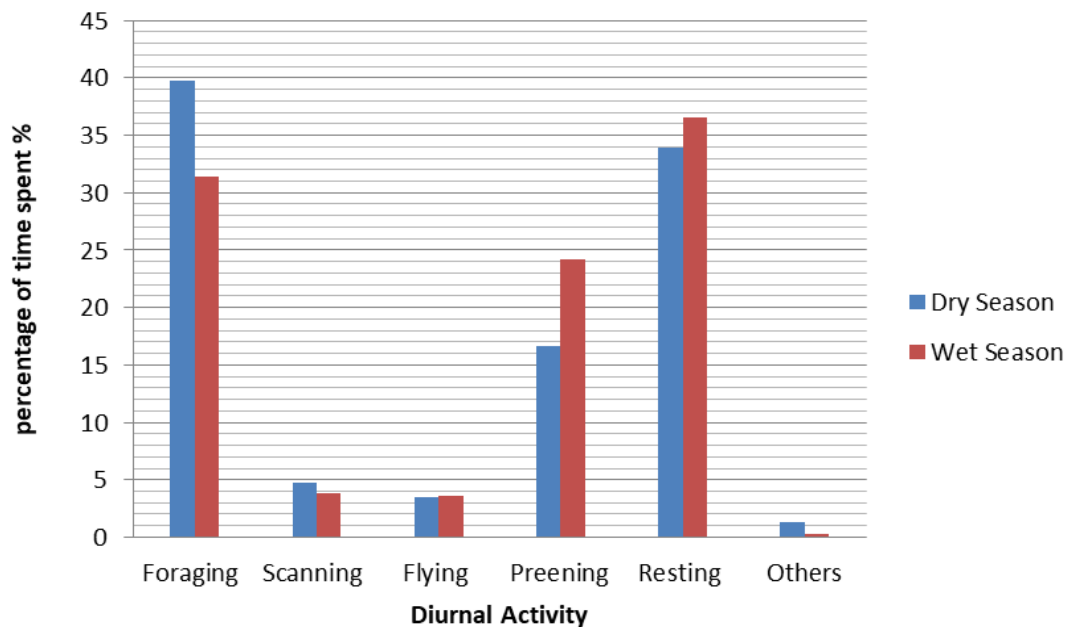


Figure 3: Percentage diurnal activity of Sacred ibis during dry and wet seasons in Chelekelaka ,Ethiopia

The proportion of time spent for different activities in Sacred ibis did not vary between seasons ($p > 0.05$) except for feeding where there was a statistically significant difference ($F_{1, 46} = 4.335$ $P = 0.043$) (Table 1).

Table 2. Mean proportion of time spent for different activities of Sacred ibis during wet and dry seasons.

Proportion time spent				
Activity	Wet season	Dry season	F	P
Feeding	53.33 $\pm$ 22.805	89.71 $\pm$ 82.497	4.335	0.043*
Scanning	6.87 $\pm$ 7.872	10.79 $\pm$ 11.143	2.563	0.116
Flying	5.87 $\pm$ 5.40	7.75 $\pm$ 9.629	0.692	0.410
Preening	39.83 $\pm$ 28.072	37.67 $\pm$ 47.597	0.37	0.849
Resting	60.08 $\pm$ 57.056	77.38 $\pm$ 120.971	0.401	0.530
Others	0.46 $\pm$ 0.932	3.38 $\pm$ 8.576	2.744	0.104

* Significant difference

The mean percentage of time spent on each activity varied in the three time slots in Sacred ibis during the dry and wet seasons (Figure 4). As compared to other activities, Sacred ibis showed a significantly higher rate of feeding in the morning hours than the mid-day and late afternoon hours ($F_{2,45} = 3.44$, $P < 0.05$) both during dry and wet seasons. On the other hand, resting rate was highest in the mid-day and late afternoon than the morning hours ($F_{2,45} = 0.479$, $P < 0.05$) during both seasons. There was no statistically significant difference in time spent for scanning ($F_{2,45} = 2.6$, $P = 0.83$), flying ($F_{2,45} = 0.914$, $P = 0.408$), preening ($F_{2,45} = 1.82$, $P = 0.173$) and other activity ($F_{2,45} = 0.54$, $P = 0.583$) both during wet and dry seasons.

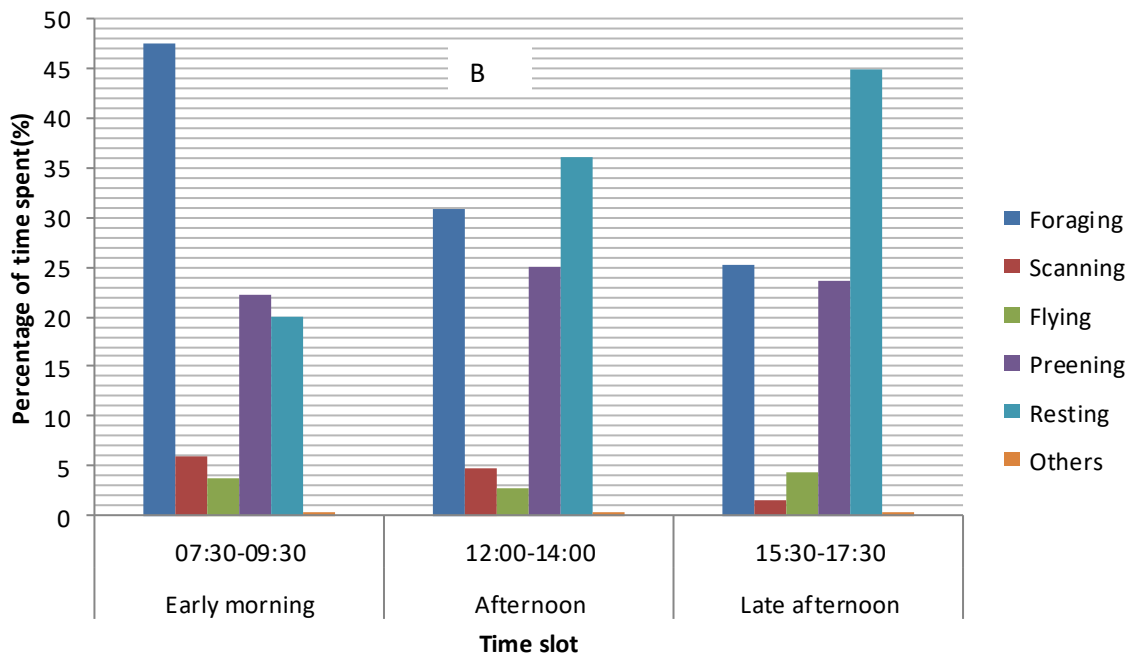
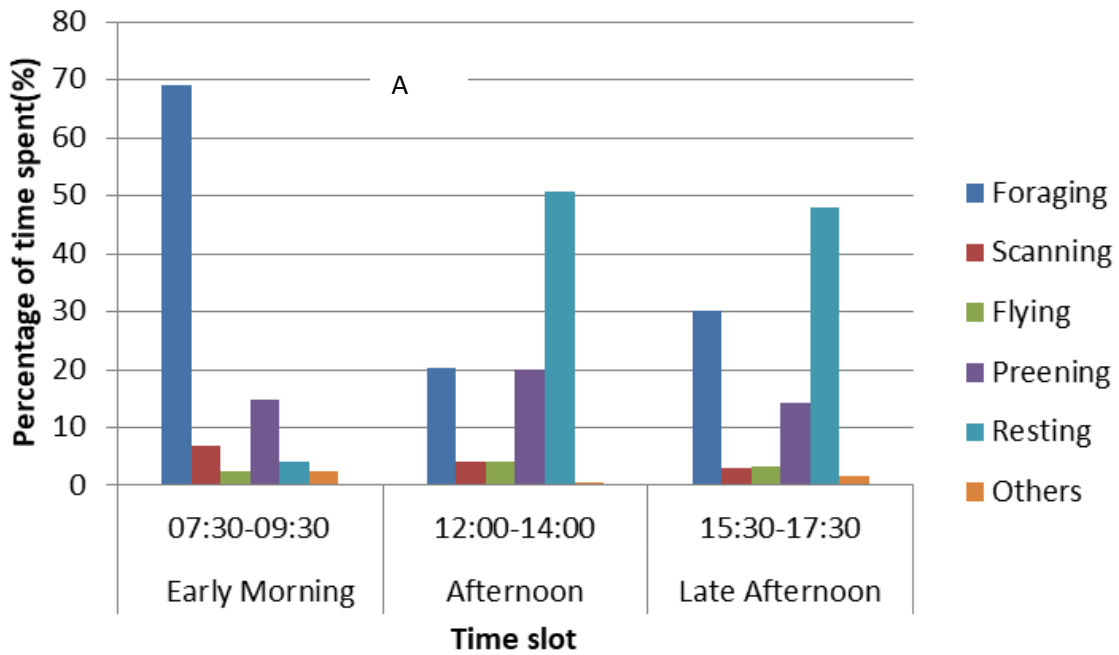
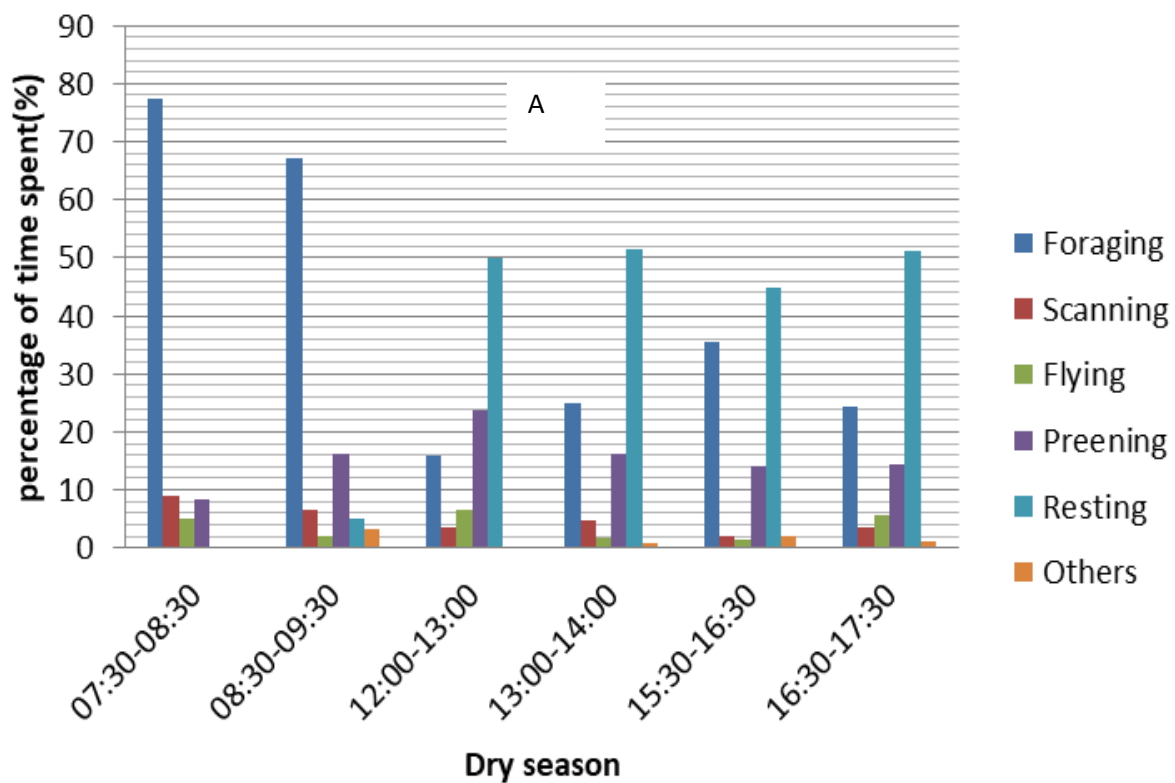


Figure 4: Activity patterns of Sacred ibis in three time slots during A) Dry and B) Wet seasons in Chelekelaka wetland ,Ethiopia

In both the wet and dry seasons Sacred ibis engaged in a variety of activities at various hour of the day (Figure 5). During the dry season Sacred ibis showed highest rate of feeding between 7:30-9:30 hours than other hours of the day (69.07%). During the wet season highest rate of feeding was recorded between 8:30-9:30 hours (59.5%). The highest rate of resting was observed between 13:00-14:00 hours(51.52%) in both the dry and wet seasons (52.34%).

During the dry season, preening activity was highest between 12:00-13:00 while scanning activity was highest between 7:30-8:30 hours. The highest rate of flying occurred between 12:00-13:00 hours (Figure 5A). During the wet season, highest rate of preening was observed between 12:00-13:00 hours while scanning activity was the highest between 12:00-13:00. The highest rate of flying occurred between 8:30-9:30 and highest rate for other activities occurred between 12:00-13:00 (Figure 5B).



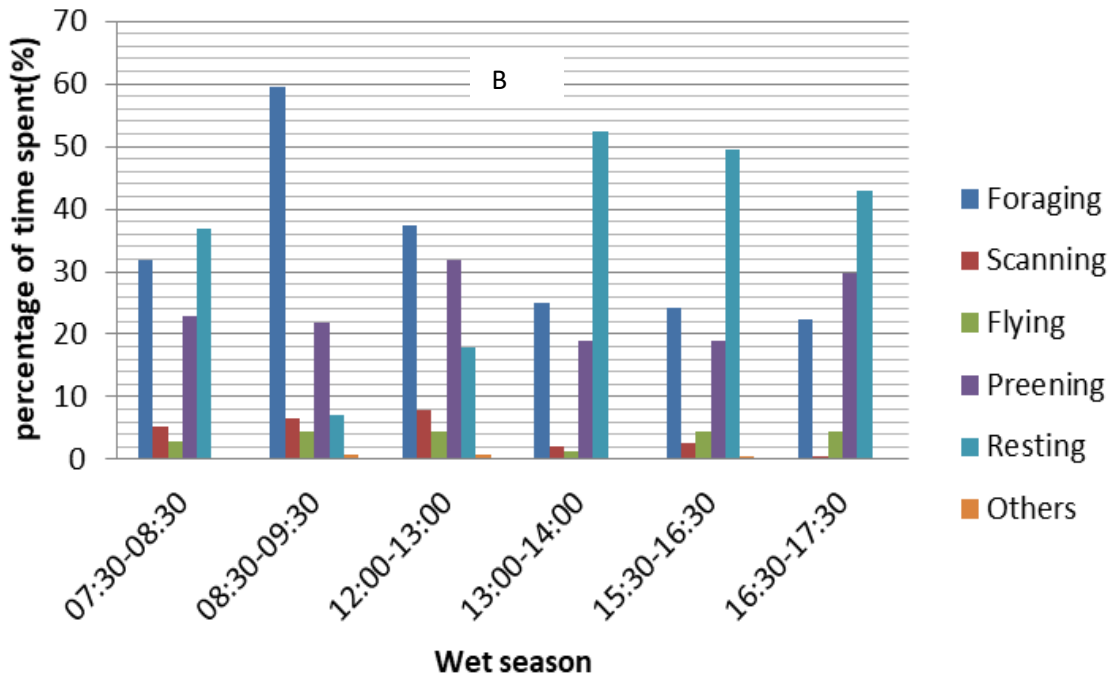


Figure 5: Diurnal activities of Sacred ibis in different hours of the day during the dry (A) and wet (B) seasons in Chelekelaka wetland ,Ethiopia

5.2. Foraging habits

Food preference

Sacred ibises were observed foraging in different habitats type such as Marshes, Muddy and Swampy areas. They were observed foraging with other species such as Wattled ibis (*Bostrychia carunculata*), Hadada ibis (*Bostrychia hagedash*), Marabou stork (*Leptoptilos crumenifer*) and Cattel egret (*Bubulcus ibis*). Sacred ibis were observed feeding on worm and insect from muddy areas. During the wet season when the lake is inundated to its full capacity, the Sacred ibis were observed feeding in the nearby pig farm around Chelekelaka wetland that provides the birds with a good food source such as worms (Plate 3).



Plate 3: Food items collected in areas where Sacred ibis foraging in Chelekelaka wetland, Ethiopia

Probing rate

During the study period, Sacred ibis used probing as the main foraging strategy. During their foraging time Sacred ibises continuously moved their heads to the ground to probe the food. The number of feeding attempts in the dry season was 5572 time per season and during the wet season was 4776. The average probing rate per minute of Sacred ibis was higher in the dry season (5.8 times/minute) than the wet season (4.9 times/minute) (Fig 6). However, there was no statistically significant difference in the probing rate between seasons ($P < 0.05$).

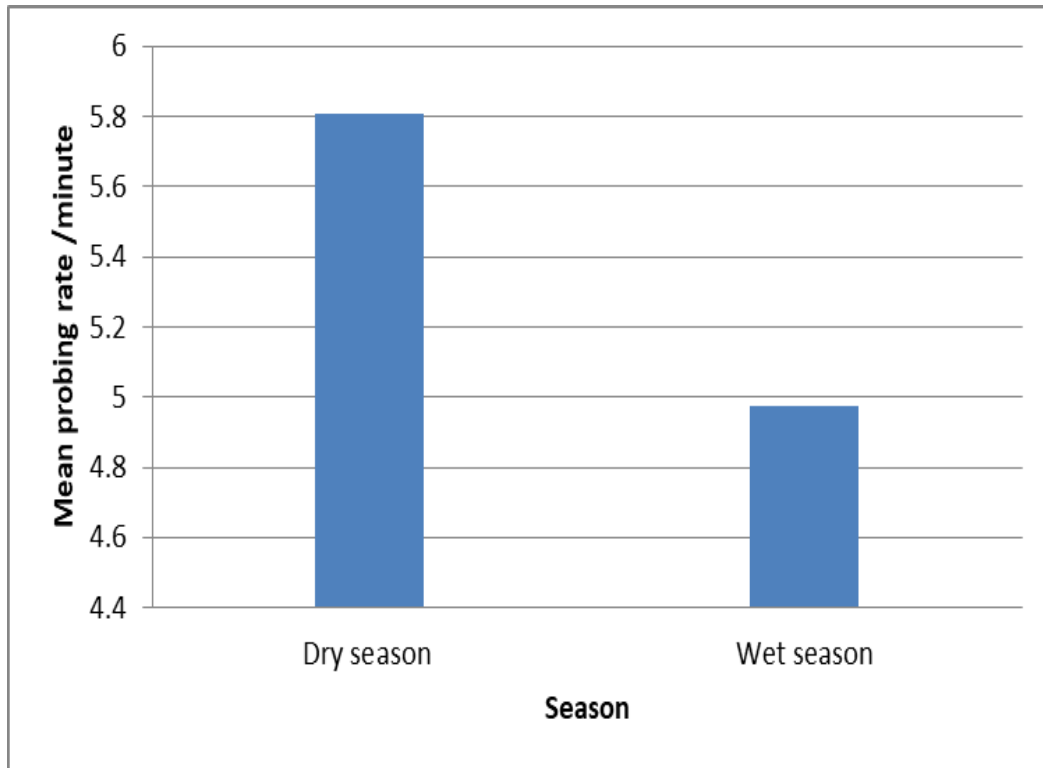


Figure 6. Mean probing/minute of Sacred ibis during dry and wet season in Chelekelaka wetland, Ethiopia

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6. DISCUSSION

This study showed that most Sacred ibis inhabited muddy habitats because such habitat serve as a good food source for the species. In addition the birds were seen exploiting anthropogenic wastes that emanated from nearby farmlands especially during the wet season where the wetland is flooded. Birds are very adaptable in managing their daily ecological needs, which can be influenced by a variety of factors including weather, season, and habitat and human disturbance (Bull, 1997). Sacred ibis showed different activities during morning, mid-day and late afternoon with in a day. Diurnal activity patterns in Sacred ibis showed that most of the birds were observed foraging, followed by resting. In this study, feeding was the most frequently recorded activity during both wet and dry seasons. This is because animals' time allocation is determined primarily by their energy needs. However the study found that feeding activity is higher in the dry season than the wet season. This may be because there are fewer food resources available during the dry season, which forces the birds to spend more time forging to meet their energy needs (Mulugeta Kassa *et al* .,2021). Furthermore, in the wet season unfavorable weather conditions creates for foraging, which is interrupted by rain, giving birds less time to forage.

Sacred ibis spent maximum time foraging in the morning hours than mid-day and afternoon hours. The Sacred ibis feed more frequently in the morning to make up for the energy they lost while metabolizing throughout the night, and feeding more in the late evening may indicate that they need to replenish their energy stores for the night (Meseret Chane and Balakrishnan, 2016). The increase in feeding in the early morning hours could be attributed to the start of their daily activities, which demand a lot of energy. The peak in late afternoon feeding may reflect the birds' need for energy for the evening (Kelly and Jeffrey, 1998). Human disturbance due to agricultural practices and including pig farming activity is common in and around the Chelekelaka wetland. These activities disturb the birds from following their normal daily activities. During the wet season, Sacred ibis highly foraged in the morning hours between 8:30-9:30 but also they feed in the mid-day and late afternoon. This may be due to the presence of rain that interrupted feeding time of the bird.

Sacred ibis spent more time resting during mid-day and late afternoon hours, making it their second most important activity. This might be attributed to the high temperature during the

midday. In times of extreme environmental heat, birds spend more time resting during the midday hours (Tewodros Kumsa and Afework Bekele, 2013) and resting activity is high during wet season than dry season due to the rainfall in wet season. Preening activity was the third main diurnal activity of Sacred ibis during wet season than the dry season. This is because birds need to groom (preen) after taking the heavy rain and this need usually increases after swimming as well (Kabir *et al.*, 2013).

The scanning activity of Sacred ibis highly pronounced during the dry season than the wet season which may have been due to the seasons relatively lower abundance of prey items such as insects which may have forced them to spend more time scanning than they did during the wet season (Kidest Ameha and Bezawork Afework, 2018). Furthermore, scanning behavior is affected by flock size and the presence of high predation risk in small flock size (Barbosa, 1995). This may be to reduce the risk of being taken by a predator, Sacred ibis increase their scan.

Sacred ibis least activity was flying during both seasons. Flying reflects behavior of escape, avoidance, or change of location in order to avoid being predated by terrestrial or aerial predators or to occupy other spots far from other bird species, which reduces competition for food and partner choice as well as antagonistic behavior (Bensierara and Chenchouni, 2019). Sacred ibis spent less amount of time for flying in the morning and mid-day but was typically observed in the late afternoon hours. This may be due to the Sacred ibis returning to the roost sites in the late afternoon hours and also the intensity of anthropogenic activities during midday hours near the Chelekelaka wetland. Many people involved in agriculture and pig farming was observed using the wet land's water at this time, which disturbs the birds' activity.

Sacred ibis foraging behavior showed that they use various microhabitats to look for food and foraging, such as the preferred habitat of Sacred ibis as muddy and marsh area during both wet and dry seasons. Sacred ibises often forage in groups of 2–20 individuals. The main prey item of Sacred ibis in this study was identified insect and worm. Sacred ibis used probing as a main strategy of foraging in the mud flats of the wetland. The mean probing rates per minute have no difference between seasons. However, during the dry season higher probing rate per minute was recorded than the wet season. This may be due to limited food resources during the dry season

where foraging requires more time to meet daily food needs particularly during the dry season when food is scarce.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The study provided important information about the Sacred ibis' feeding and activity patterns, including how season and time of day affected these behaviors. Seasonality and time of day were found to be the main determinants of the Sacred ibis' feeding and activity patterns.

Sacred ibis actively forage in the marsh and flat muddy habitat both during the wet and dry seasons. They feed highly during the morning hours resting during mid-day and late afternoon. Sacred ibis mainly consume insect and worms in both dry and wet season,

The degradation of Chelekelaka wetland caused by irrigation and overgrazing through decline the food availability for the Sacred ibis and other wetland bird species in the area. As a result, it is crucial to understand how the effects of season and time of day on the activity pattern and feeding behavior of birds are related through scientific study.

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7.2 Recommendations

Based on the results of the current study, the following suggestions are made:

- ❖ To understand the species' current status, more research on population status and foraging behavior in the Chelekelaka Wetland is required.
- ❖ Many people live around the Chelekelaka wetland depend on the wetland for agriculture and irrigation system causing disturbance to Sacred ibis and affect their normal behavioral activities. Hence, emphasis should be given to conservation of the wetland and the water bird including Sacred ibis.
- ❖ The Chelekelaka wetland need high conserving strategy because the urban people waste product is directly dumped in the wetland this cause the wetland quality degrade.
- ❖ The results of this study relied on data collected from one study area (Chelekelaka), replication of such a study in other habitats over a longer time period will be critical in acquiring large data sets for different populations. Furthermore, longer-term studies will be necessary to gather more information about the species and facilitate conservation efforts.

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APPENDICES



A)



B)

Appendix 1: Sacred ibis in different activities a) Resting b) Scanning (Photo: Hilina Sisay, 2022).



A)



B)



C)

Appendix 2: Foraging habitats of the sacred ibis a) Grass land b) Marsh land c) Farmland(Photo
:Hilina Sisay ,2022)