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Activity Pattern and Feeding Behaviour of African Jacana (*Actophilornis africanus*) in Lake Hawassa

A Thesis Submitted to the Department of Zoological Science in Partial Fulfillments for the Requirements for the degree of masters of Science in Ecological and Systematic Zoology

By

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Abstract

Activity Pattern and Feeding Behaviour of African Jacana (*Actophilornis africanus*) in Lake Hawassa.

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The present study documents activities and diet of African jacana (*Actophilornis africanus*) in Lake Hawassa. Data were collected during the wet (July- August) and dry (January- February) seasons in 2017 using scan and focal sampling methods. Repeated observations were administered to collect data on activity pattern and foraging behaviour of African jacanas. Activity patterns including feeding, scanning, flying, preening, resting and others were observed. African jacana feed primarily on insects (63.7%). They also feed on worms (16.2), larvae (5.4), snails (5%), seed (3.7%) and other (6%) during the wet season and during the dry season insects (55.6%), worms (12.2 %), larvae (8.2%), snails (7.1%) seed (6.5%) and other (10.3%) There was significance difference in the type of food consumed by African jacana during the wet season ($F_{1\ 39} = 7.86$, $P< 0.05$) and during the dry season ($F_{1\ 39} = 3.11$, $P< 0.05$). There was no significance difference in the type of food consumed between seasons ($F_{1\ 39} =1.48$, $P> 0.05$). Major activities of the species were mainly feeding 95.8 ± 5.6 and 149.3 ± 8.9 during the wet and dry seasons respectively. Feeding activity was intensive and reached its peak in the morning (6:00 - 9:00) and late afternoon hours (4:00 – 6:00). Resting was more during the mid-day (12:00 – 1:00). During the dry season, there was significant difference in the rates of feeding ($F_{0.05,\ 118} = 15.24$, $P < 0.05$) in the three time periods. The mean feeding rates were significantly higher in the morning than late afternoon (Post hoc Tukey HSD, $p < 0.05$). There were significant differences in the mean rates for scanning ($F_{0.05,\ 118}= 6.9$, $p < 0.05$), flying ($F_{0.05,\ 118}= 5.03$, $p< 0.05$), resting ($F_{0.05,\ 118}=4.33$, $p < 0.05$) during the different periods. Further ecological studies on African jacana should be conducted to get more information about the bird and facilitate conservation measures in the study area.

Key Words: Activity patterns, Feeding ecology, African jacana, Lake Hawassa.

1. INTRODUCTION

1.1. Background

Ethiopia is a vast ecologically diverse country blessed with extensive and unique environmental condition (Zerihun Girma *et al*., 2017). This in turn led to the formation of diverse ecosystems which contributed for the tremendously diverse avifauna. Over 926 species of birds are recorded from Ethiopia of which 21 species are endemic to Ethiopia, 14 other bird species are shared with Eritrea and 19 are globally threatened (Lepage, 2006).

Ethiopia, with its different geological formations and climatic conditions, is endowed with considerable water resources and wetland ecosystems. It includes 12 river basins, 8 major lakes, many swamps, flood plains and man-made reservoirs. According to the Ethiopian Forestry Action Programme (EFAP) (1989), 110 billion $m^3$of water runs off annually from the above sources. Major river and lake systems, together with their associated wetlands are fundamental parts of life and natural ecosystems. Wetlands shelter countless species of fauna and flora, including birds (Carp, 1980). Many wetlands are prominent because of their birdlife. Indeed, around 12% of all African bird species are found in and around wetlands (Mafabi, 1995). In Ethiopia, 204 (around 25%) of bird species are wetland-dependent (EWNHS, 1996). Although many of these birds are known, their habitats remain uninvestigated.

Lake Hawassa is one of the many freshwater shallow lakes found in the central Ethiopian Rift Valley. The sum total of aquatic and terrestrial habitats adjoining the lake facilitate for the rich diversity of flora and fauna compared to other Ethiopian Rift Valley lakes (Pattnaik, 2014).

Scores of species with different forms of plants, animals and micro-organisms make the lake extremely bio-diverse. The littoral area is covered with emergent and submerged macrophytes that

serve as shelter, thrashing and proliferation zones for several benthic and pelagic zooplanktons such as Protozoans, Rotifers, Crustaceans, and several weed bed fauna like annelids, insects as well as fishes (Pattnaik, 2014). The littoral and open water of the lake is dominated by wide-ranging delivery of sedges (*Cyperaceae*), cattail (*Typha sp*.), the floating grass *Paspalidium germinatum* and hydrophytes such as the Blue water lily (*Nymphaea coerulea*), water cabbage (*Pistia stratiotes*) and Wolfia arrhiza, considered to be the smallest flowering plant in the world (Girma Tilahun *et al*., 2010).

The lake is among one of the biggest bird sanctuaries in the rift and homeland for several hundred species of water birds, including local and Palaearctic migrants. About 80 wetland birds of which 24 palearctic migrants are reported around the lake (Pattnaik, 2014). One of the water birds found in the area is Jacana. little is known about the biology of any of the Jacanidae, a circumtropical family of shorebirds that inhibit freshwater swaps and marshes. Lack of knowledge reflects the limited field research on tropical aquatic birds in general (Lack, 1968). Bird's activity study is significant in understanding its life history, physical condition, food availability, social structure, environmental condition as well as ecological conditions (Asokans *et al*., 2010; Aissaoui et al., 2011). Daily activity is influenced by an individual's need and its interactions with organisms, both conspecific and with other species, environmental factors, such as ambient temperature, humidity, illumination and precipitation and ecological factors, such as group size, habitat, food availability and predation (Lillywhite and Brischoux, 2012). Time-activity patterns are especially suitable for comparative studies, such as those among seasons of the year, sexes and habitats (Holmes et al., 1979). In particular, data on activity pattern and feeding behaviour of African jacana are lacking except its mating system. Here, this study describes the time allocated to

different daily activities by African jacana among seasons, time blocks, habitats, food item consumed and food handling techniques in Lake Hawassa.

1.2. Objective

1.2.1. General objective

The general objective of this research is to study the activity pattern and feeding behavior of African jacana in Lake Hawassa.

1.2.2. Specific objectives

The specific objective of this study are

- To assess the activity pattern of African jacana with respect to the time of the day and seasons.
- To assess the feeding behaviour of African jacana.
- To identify the food items consumed by African jacana.

1.3. Research Questions

1. Does Hawassa Lake and surrounding habitat provide suitable feeding ground to African jacana?
2. Does activity pattern of African jacana vary depending on seasons and time of the day?
3. Does the diet of African jacana vary depending on seasons and time of the day?

1.4. Significance of the study

The current research will help to:

- Develop a knowledge and understanding of African jacana and its habitat
- Reveal effect of season and time on the activity pattern and foraging behaviour of the bird.
- Create awareness and appreciation of benefit of the wetland for a bird.

1.5. Limitation of the study

While doing this thesis, the researcher has faced various problems like:

- Anthropogenic disturbance when the human presence was high in the study site of the birds by hiding themselves, making it difficult to conduct the research.
- During the wet season, in the presence of heavy rain, the birds were difficult to find.

2. LITERATURE REVIEW

2.1. Physical characteristics

African jacana ranges in length from 23 to 31 cm and 137 to 261 g (Melissa, 2005). Jacanas have long, slender necks and extremely long toes and claws, as long as 10.2 cm. Their large feet allow them to balance on and move over lily pads and other floating vegetation (Melissa, 2005). The adult has rich chestnut to rufous-cinnamon upper parts, but rump and secondaries are darker and primaries are black. The upper wing is glossy sheen in good lighting. The black hind neck contrasts with the white fore neck. The tail is short. The under parts are darker maroon-chestnut, except the chin, throat and fore neck which are white, turning golden yellow on the upper breast. On the head, the pale blue bill extends to a large pale blue to grey blue frontal shield. The rest of the crown is black. The sides of the head are white. The eyes are dark brown. The immature has blackish washed brown crown and hind neck. It has a white super cilium and the frontal shield is absent or slightly developed. The upper parts are pale brown. The under parts are white, with indistinct yellowish breast band (Plate 1) (Redman *et al.,* 2009).

Plate 1. African jacana (*Actophilornis africanus)* (photo: Kidest Ameha 2018)

2.2. Taxonomy

Eight extant species in six genera are recognized in the family Jacanidae. Four genera are monotypic and occur on three continents: *Microparra* (Africa)*, Irediparra* (Australia), *Hydrophasianus* and *Metopidius* (Asia). Two other genera consist of two species: *Actophilornis africanus* (Africa) and *A. albinucha* (Madagascar), *Jacana jacana* (South America) and *J. spinosa* (Central America). The genera of jacanas are mainly allopatric, but some co-occur in portions of Asia (*Hydrophasianus* and *Metopidius*) and Africa (*Actophilornis* and *Microparra*). The two *Jacana* species co-occur and hybridize only in a small area of western Panama (Wetmore 1965). Until recently, relationships of the jacanas to other groups of birds were poorly known. At present, they are grouped under Charadriiformes and probably are most closely related to painted-snipes, family Rostratulidae (Kitto and Wilson, 1966; Strauch, 1978; Sibley and Ahlquist, 1990).

African jacana is grouped under family Jacanidae. The family jacanidae consist of 8 extant species of jacana (Table 1).

Table 1. Taxonomy of jacanas

Common name	Scientific name
Bronze Winged jacana	*Metropidius indicus*
Wattled jacana	*Jacana jacana*
Northern jacana	*Jacana spinosa*
Comb creasted jacana	*Irediparra gallinacea*
African jacana	*Actophilornis africanus*
Madagascan jacana	*Actophilornis albinucha*
Lesser jacana	*Microparra capensis*
Pheasant tailed jacana	*Hydrophasianus indicus*

2.3. Vocal and visual communication behaviour

As reported by Bonkewitzz (1997), the eight types of vocalization in the African jacana are as follow:

(a) *Peep* call: A whistling sound performed by chicks, reaching nearly 4 kHz when they demanded the father's presence.

(b) *Harsh call:* This is a very variable call, but basically consisted of four harmonics extending from 2.5 kHz to 4.0 kHz and the duration averaged 0.21s (n = 14). This vocalization functions mainly as a territorial signal and was always recorded during chasing behaviour. Sometimes the

harsh call was effective as a sexual call, especially when it was uttered by the female. The *harsh* call elicits the same call in neighbouring jacanas and is also capable of driving them off. This supports the idea that the call is strongly related to territorial signaling behaviour.

(c) *Screech* call: This call is very high-pitched, reaching 5 kHz with up to four harmonics. The duration averages 0.23 s (n = 21), and was performed as a warning signal. Sometimes this call was performed in a group and was accompanied by an upright posture. Both the *harsh* and *screech* vocalizations were recorded during disturbances (in cases of alarm), but with the difference that the *harsh* call was recorded particularly when the bird was accompanied and the *screech* usually when it was alone. The *screech* elicited the same type of call from conspecifics, but did not cause any movement such as flight.

(d) *Purring* call: This was low-pitched, similar to a cat's purring. It lasts about 0.13 s (n = 24) and consists of three harmonics from 0.5-3.0 kHz. This particular call was associated with both pre-copulatory and post-copulatory behaviour. Sometimes this call was used by the male during sexual soliciting. *Purring* elicited the *guang* call, random movements and *more purring* as a response from other jacanas.

(e) *Chick-calling* call: This was a flute-like sound performed by the male to summon the chicks

(f) *Harsh Trilled Call* Consisted of three to four harmonics extending from 1.0-4.5 kHz of 0.8 s duration. In this type of harsh vocalization, it is easy to distinguish the notes and the lowest harmonic. This particular call serves the same purpose as harsh vocalization, especially during distraction displays in males.

(g) Fear call: This was a very long call that lasts 1.8 s but varied in frequency from 3.0-7.0 kHz, starting with three harmonics and ending with two. This was recorded only when the birds were in extreme danger.

(h) *Guang* call: This call occurred mainly during sexual solicitation. The call typically comprised two or three harmonics. The average duration was about 0.09 s (n = 29)

Visual display and varying postures among African jacanas were reported by Tarboton (1992). This includes aggressive threat display and alarm display.

Aggressive threat displays

(a) *Upright* posture: the bird extends the neck with the nape feathers upright and utters the *harsh* vocalization. It has been recorded in the presence of passing crocodiles, monitors and when allospecific birds like Blacksmith Plovers *Vanellus armatus* were on the copulation platform of the jacanas. If the high-intensity *upright* posture was assumed, the jacana faced the intruder whereas from a low-intensity position it merely gave a sidelong glance (Plate 2A).

(b) *Neck-retracted* posture: this was recorded in females during visits to the territories of incubating males (Plate 2B). The neck is completely retracted and the bird tends to walk slowly. In two cases this posture was seen while the bird was pattering on the water in a very similar way to that of males when they perform distraction displays.

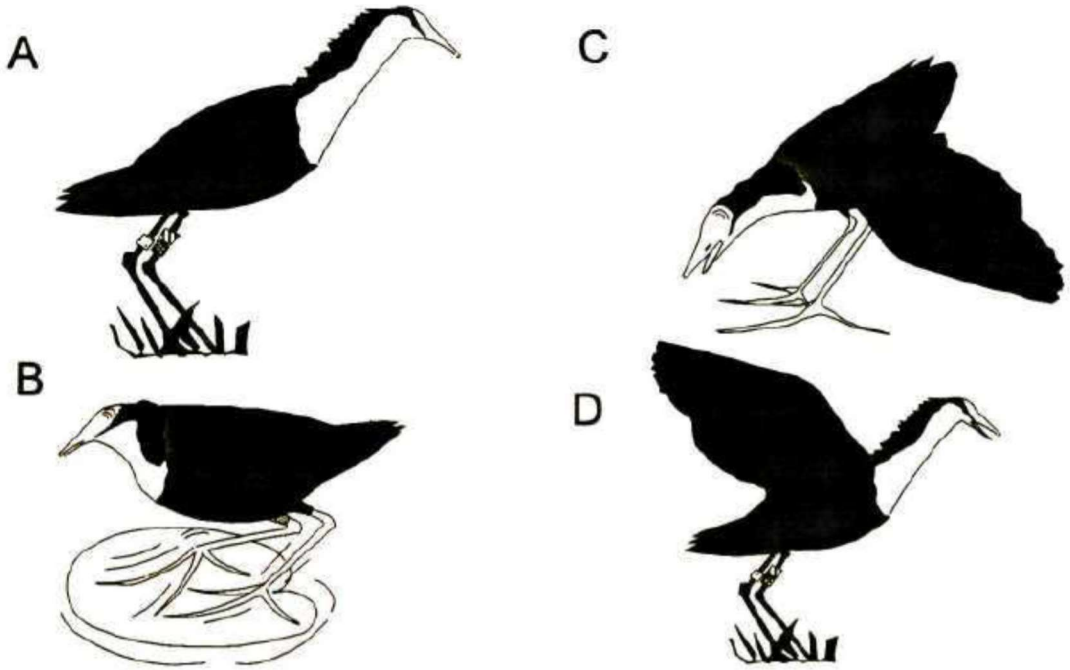

Plate 2. Aggressive threat displays of the African Jacana. A = Upright, B = Neck Retracted, C = Wing Down; D = Spread Wing (source: Bonkewitzz ,1997)

(c) *Wing-Down* posture: assumed chiefly by males towards females in sexual encounters and towards other males during territorial confrontations (Plate 2C). The posture is always accompanied by a strong *guang-guang* call which is somewhat different from the sexual soliciting call. The most characteristic feature of this display is half-spread wings. At high intensity one or both wings are completely spread.

(d) *Spread-Wing* posture: this is the most common display recorded during the study period. this display considers as typically territorial and seen only performed by males. The salient feature is raised wings while the jacana utters *harsh* calls (Plate 2D).

The Alarm Display

Two main observations support the idea that the upright posture that accompanies the screech call is elicited more by an impulse to escape than by aggression.

(a) The posture occur mainly when a sudden disturbance happened, such as the sudden appearance of an eagle, crocodile or any threatening intruder. The interval between the appearance of the intruding figure and the reaction was sometimes so short that there was no time to escape. However, as a general rule, aggression took more time to manifest itself than the drive to escape.

(b) The upright posture was always present as part of the post-copulatory display, which means that, once the sexual act was complete, the sexual drive decreased, as did aggression. The male almost always performed the *upright* posture first and then the female joined him. This suggests that the male is less aggressive than the female and that is why the male adopted the *upright* posture first.

2.4. Feeding behaviour and micro-habitat

The foraging behaviour of birds is significantly influenced by the type of feeding habitat they depend on (Mansor and Mohdsah, 2012). A foraging substrate is the micro-habitat from which birds derive their food items. Focusing on foraging habitat explores how birds utilize different food niches to adapt to the habitat since the portioning of food resource is important for the survival of avian species. Knowledge on foraging ecology of wet land birds has become fundamental in providing an understanding of the ways in which species in a habitat partition their resources (Schulze *et al*., 2000). The African jacana prefers lily leaf for foraging substrate since insect abundance is higher in this micro-habitat (Bonkewitzz 1997) (Plate 3).

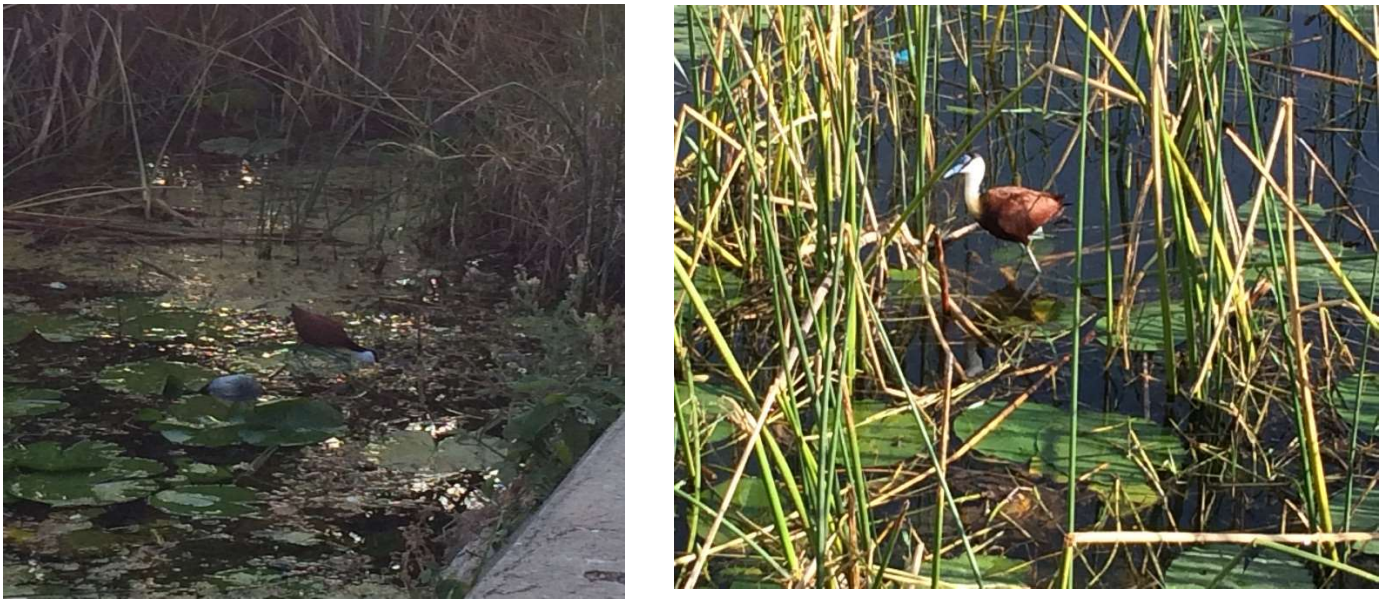

Plate 3. African jacana feeding and scanning food items on lily leaf (photo: Kidest Ameha 2018)

2.5. Reproduction behaviour

The mating system is mainly polyandrous, one of the most uncommon systems of reproduction in vertebrates, in which the female may mate with up to seven males (Tarboton 1992). The sexual roles are partially reversed: females are dominant over males and patrol a superterritory containing the male's subterritories. Incubation and rearing of chicks are performed by males while females spend most of the time mating, foraging and defending their territories. Egg laying season is year round, peaking from November-March. It lays 3-5, usually 4 eggs (Hockey *et al*., 2005). The African Jacana shares the same environment with the Lesser Jacana but the latter is exclusively monogamous (Tarboton and Fry, 1986; Urban *et al*., 1986).

The nest is a flimsy, damp head of aquatic plant steams, in fact the eggs are often just 2 cm above the water surface.it is typically placed out in the open or concealed by vegetation, especially Willoherb (*Ludwigia stolinifera*). Due to their close proximity to the water surface the brood are vulnerable to changing water levels, which can cause the breeding pair to hastily assemble a new

platform to move the young or eggs to (Hockey *et al*., 2005). A peculiar behaviour of African Jacana is chick-carrying which is performed by males to protect the chicks from cold weather and as a way to move the brood to a secure place in case of danger. They are often incubated under the males for up to 18 days. In fact, when they are small the male can fit up to four chicks under its wings. The young take their first flight about 39-44 days old, becoming independent at 40-50 days old (Hockey *et al*., 2005).

2.5.1. Chick-carrying behaviour

Chicks within a few days of hatching nestle under the father's wings. This behaviour is both for brooding and to conceal the chicks from predators. *Chick-carrying* behaviour is initiated when the father utters a low-pitched *chick-calling* call. When the chicks come closer to the father, he opens his wings slightly, allowing them to huddle underneath. Then he walks slowly with the chicks clamped under each wing taking his young away from the danger. If he is followed, he will drop the chicks which immediately submerge in the water, keeping only the bill above the surface (Tarboton, 1992)

The male jacana distance himself by flight from the chicks before performing distraction displays. If the chicks are still in danger, they may shift their position by swimming. The *harsh* vocalization warns the chicks to remain submerged and motionless. While this is advantageous for disturbances of short duration, it can prove fatal for a prolonged period (Tarboton 1992)

2.5.2. Sexual behaviour

Bonkewitzz, (1997) described a distinctive courtship sequence in three steps.

The first part of the pre-copulatory stage is the sexual soliciting call *(guang* call). However, a *harsh* call and *a purring* call were recorded especially when the partner was close to the copulatory site.

During the display, the jacana bend the body with the neck slightly curved upwards. Very often ground-pecking behaviour was observed. Sexual soliciting is performed by both sexes always in one or two designated areas of the male's territory.

The second step is head down postures. It did not differ much in appearance from sexual soliciting behaviour except in the utterance of the *purring* call. Either the male or the female greeted the partner by presenting the sky-blue frontal shield and the black band on the neck. In each case, the female remained motionless while the male walked around her, both sexes maintaining the same posture. Head-pecking occurred at the start of copulation. The pecks is aimed at the black side of the neck of the female.

The third step is post-copulatory. Immediately after copulation the *head-down* posture continued with contact behaviour and then an *upright* display was performed. This is the same type of *upright* posture reported during the *screech* call but is less prominent. The neck is stretched strongly upwards but the nape feathers are not raised. The *alarm upright* posture was usually performed first by the male followed by the female (plate 4).

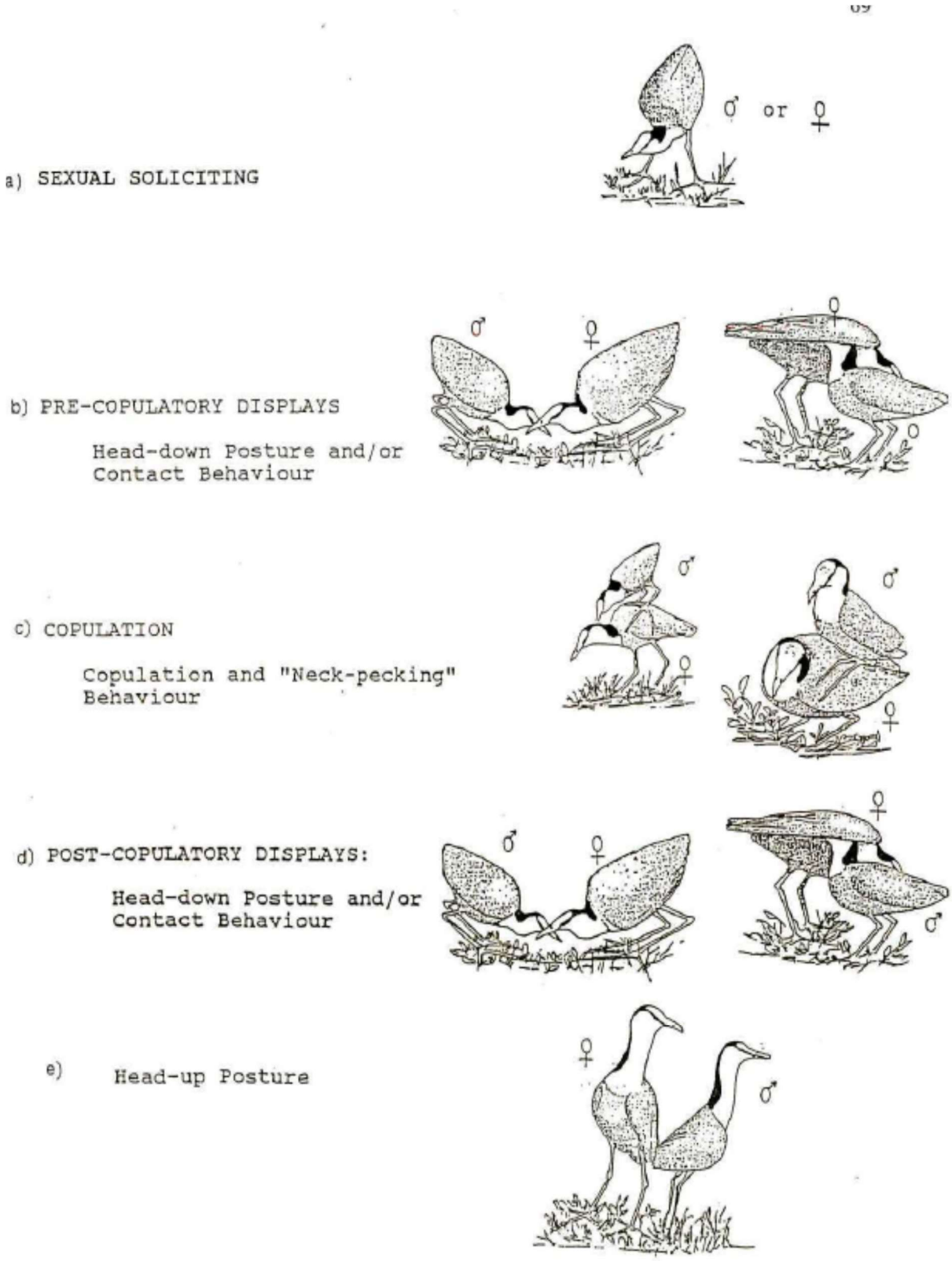

Plate 4. Courtship behavior sequence of the African jacana (source: Bonkewitzz ,1997)

2.6. Population and conservation status

African jacana global population is about 1,000,000. This species has an extremely large range, and hence does not approach the thresholds of vulnerable under the range size criterion (Extent of occurrence < 20,000 km^2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation). The population trend appears to be stable; hence the species does not approach the thresholds for vulnerable under the population trend criterion (>30% decline over ten years or three generation). The population size is extremely large, hence does not 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 evaluated as Least Concern (IUCN, 2017). The species is locally threatened by wetland degradation and loss through flooding.

3. Materials and methods

3.1. Description of the study area

Lake Hawassa is located in the Southern Nations Nationalities and Peoples Regional State (SNNPR) about 275 km south of Addis Ababa. The lake lies between 6°33'-7°33' N and 38°22'-38°29' E. (Fig. 1) (www.snnprs.gov.et).

It is the smallest of all the Ethiopian rift valley lakes having a total surface area of 95 km^2 and a total drainage area of 1, 371.6 km^2. Its mean depth is 11 meters while the maximum depth of the lake is 22 m. The lake is found at a surface elevation of 1,686 m above sea level. It is about 16 km long and 8 km wide and has an estimated volume of 1.3 billion cubic meters (Zinabu Gebremariam, 2010).

3.1.1 Topography

The majority of the watershed is flat to gently undulating but bounded by steep escarpments. Mostly sloppy (56%) and flat to gentle (0%-8%) with a further 33% moderately sloping (8%-30%) and only 5% steep to very steep (>30%) (Dessie, 1995).

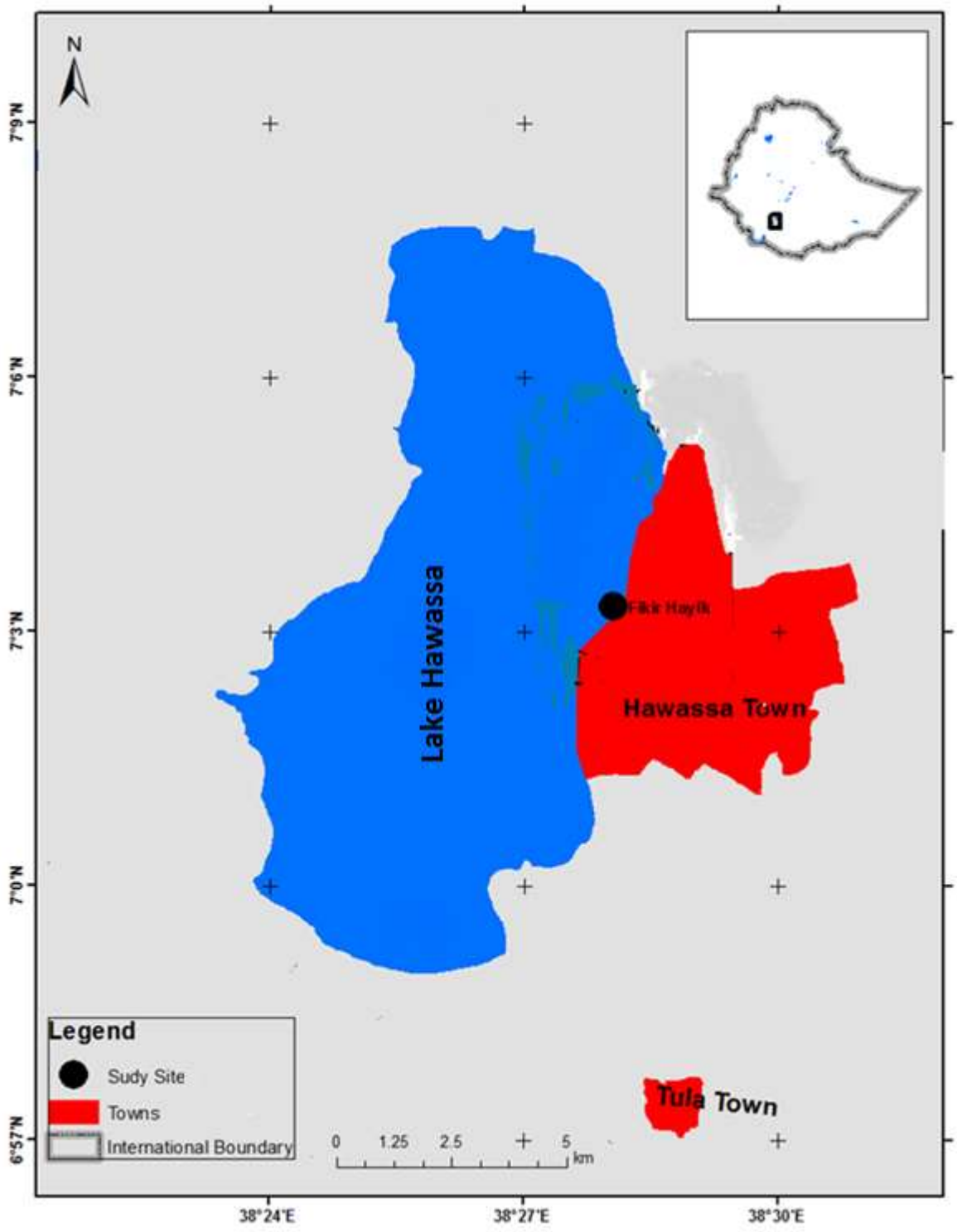

Figure 1: Map of the study area.

3.1.2. Climate

3.1.2.1. Rainfall

According to Dagnachew Legesse *et al*. (2003), the watershed is characterized by three main seasons. The long rainy season in the summer from June-Sepetember is known locally as Kiremt and is primarily controlled by the seasonal migration of the inter-tropical convergence zone (ITCZ), which lies to the north of Ethiopia at this period. The wet period represents 50%-70% of the mean annual total rainfall. The dry period locally named as 'Baga' extends between October and February when the ITCZ lies to the south of Ethiopia. During March and may, the "small rain" season locally named as 'Belg' occurs when about 20%-30% of the annual rainfall falls (Dagnachew Legesse *et al*., 2004). The climate in the area varies from dry to sub-humid according to the Thornthwaite's system of defining climate or moisture regions (Dessie, N., 1995).

As extracted from www.worldweatheronline.com, monthly rainfall record of Hawassa, the heaviest precipitation is during May-July and September-October (Fig. 2).

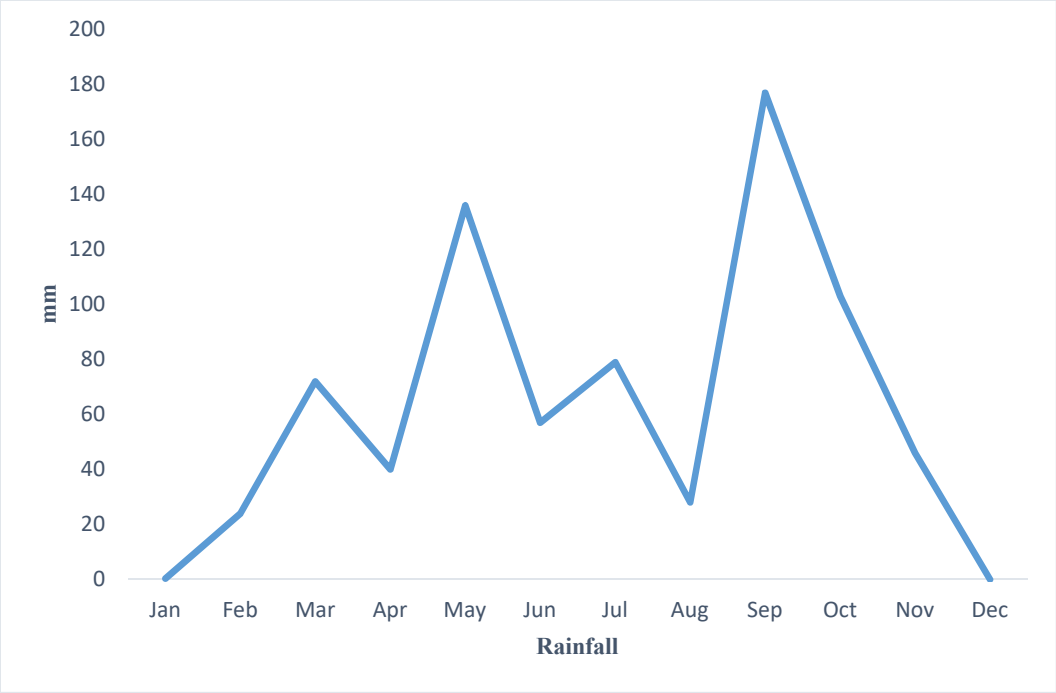

Figure 2: Distribution of monthly rainfall at Hawassa (source: www.worldweatheronline.com)

3.1.2.2. Temperature

The warmest months of the year are February and April, with an average temperature of 22^{0}C. The lowest average temperature in the year occur in December when it is around 18^{0}C (Fig. 3).

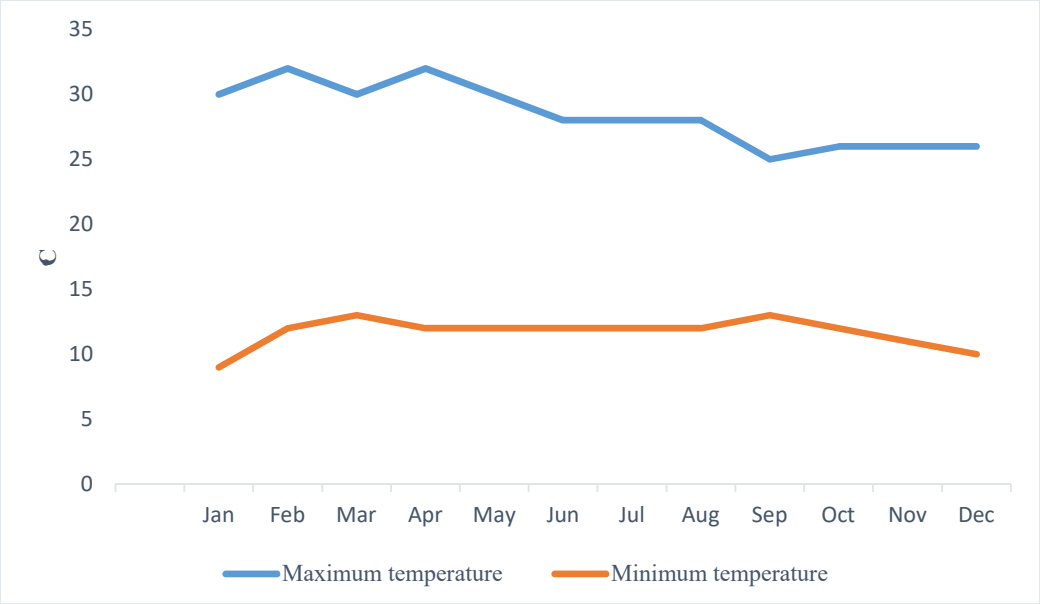

Figure 3: Distribution of monthly temperature at Hawassa (source: www.worldweatheronline.com)

3.1.3. Flora

The shallow nature of the water has led to the production of a wide shoreline. The terrestrial ecosystem around the lake consists of *Acacia* woodlands, wetland vegetation while the bank of the water is covered by lush grasses and sedges. The various emergent, submerged and floating wetland flora include *Ludwigia stolonifera, Potamogeton schweinfurthii, Typha angustifolia, Paspalidium germinatum and Nymphaea caerulea* (Plate 5) the latter being a favored leaf for African jacana. Rangelands are rich in grass species including *Cynodon dactylon, Hyparrhenia sp., Cenchrus ciliaris, Heteropogon contortus and Hypoestes species* (Pattnalk, 2014)

Plate 5: Water lily (*Nymphaea caerulea)* (photo: Kidest Ameha 2018)

3.1.4. Fauna

About 80 wetland birds of which 24 are Palearctic migrants are reported around the lake (Pattnalk, 2014). Of these birds, four species are endemic recorded from the woodlands nearby. They are Yellow-fronted Parrot *Poicephalus flavifrons*, Black-winged Lovebird *Agapornis taranta,* Banded Barbet *Lybius undatus and* Forest Oriole, *Oriolus monacha***.** Wetland migrant birds include Egyptian Goose, *Alopochen aegyptiacus,* Cotton Pygmy Goose, *Nettapus coromandelianus,* White-faced Wistling Duck, *Dendrocygna viduata,* Spur-winged Goose, *Dendrocygna viduata,* Knob-billed Duck, Red-knobbed Coot, *Sarkidiornis melanotos,* and African Fish Eagle,

Haliaeetus vocifer. No amphibian fauna was reported from and around the lake while the reptilians are represented by a skimpy number of monitor lizards (Pattnalk, 2014). The lake is also basically dominated by large populations of Rotifers, Copepods, Cladocerans and Dipterans (Chioronomous) insects. The Cilliophorans especially the Paramecium was also represented by quite a good number of species (Pattnalk, 2014)

3.2. Materials

The materials that were used during the study period were binoculars to observe the birds, stopwatch to measure the time during their activities and data sheet, pencil and other stationary materials to record data during the study period.

3.3. Methods

3.3.1. Preliminary survey

Ecological survey of birds in and around Lake Hawassa was carried out to gather relevant information. In this survey, an overall view of birds specifically to African jacana of the area was conducted. Information 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 taken on monthly basis (total 40 days: 20 days during the wet season and 20 days during the dry season) for two months depending on weather conditions and time of the season when most of the African jacana were active. Data were collected early in the morning (6:00 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 pattern and foraging behaviour of the African jacana. In addition, photographs were taken to confirm their activities.

3.3.2.1. Activity patterns

The diurnal activity patterns of African jacana were collected during both wet and dry seasons. Activities were recorded using scan sampling method throughout the study period (Altiman, 1974). During the observation period, a group or an individual bird was followed at a distance of 5-10 m. Five minutes scan samples were taken at interval of 10 minutes. The observations were made from early morning to late evening dividing the day into three time slots; morning 6:00-9:00 h, mid-day 12:00-1:00 h, then in late afternoon from 4:00-6:00 h. 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

To collect data about the diet composition of African jacana, repeated observation were carried out during the wet (July- August) and dry (January- February) seasons. Observation were made with the aid of binoculars and direct observation. Time spent on foraging was recorded using focal sampling methods following Sutherland *et al*. (2005).

Individual bird was followed from a distance of 5-10 m. Observation was made under good weather conditios, avoiding bad weather conditions (when drizzling and raining) (Murphy, 1987; Schulze *et al.,* 2000). Data were collected early in the morning from 06:00-10:00 h and late in the afternoon from 14:00-18:00 h, when most of the avian species were engaged in feeding activities (Buskirk and McDonald, 1995). To find the focal bird, the observer walked slowly (approx. 4km/h) across the study area and every bird that was actively feeding identified as the focal bird. The bird was first observed for 10 seconds without recording any data. This time period minimized the likelihood of recording only the conspicuous behaviour, and also ensured that the bird resumed normal activity patterns in the presence of the observer (Block, 1991).

Observation of birds while feeding was made for 10 minutes per individual. Time data on behaviour (per minute) was collected. A stop-watch was used to time the duration of activity. Observation began as soon as the focal bird began foraging. When focal individual stopped foraging or was lost from sight before 30 seconds (of the one minute observation) elapsed, data was not considered for analysis. When the focal bird stopped foraging or lost from sight, another individual bird within the flock was selected as the focal bird in order to complete the observation period (De Melo and Guiherme, 2016). Data were obtained on food capture and handling technique- (i) picking- birds walk on the ground and pick prey along the route; (ii) run-picking-picking of insect prey preceded by a short sprint, time of feeding, food type and type of foraging

substrate selected for food captue. Each distinct jab or peck at the foraging substrate was considered to represent a feeding hence number of pecks per minute accurately represented feeding rates (Davis, 1997). The records were treated as independent in the analysis (Fitzpatrick and Bouchez, 1998). To avoid re-sampling the same bird, the observer moved 150 m from the location before sampling of the next bird began (Munoz and Colorado, 2012).

3.4. Data analysis

Data were tested for the normality using the R-QQ plot for normality and Shapiro-Wilk Test. Comparison was made on means for samples obtained from a normal distribution. Multiple comparison test (Tukey HSD) was used to make multiple comparisons for mean rates in activity pattern recorded in the morning (6:00-9:00 am), mid-day (12:00-1:00) and late afternoon (4:00-6:00). Chi-square test was done to infer differences in foraging habitat preference of African jacana. To determine whether there was a difference among activity and food item consumed in different seasons (wet season and dry season) a one-way analysis of variance (ANOVA) was used. In all the statistical tests conducted, the level of significance was always set as $\alpha < 0.05$. All measured values are shown as mean ± SE. The analysis described above were conducted using SPSS software version 20 and Microsoft EXCEL.

4. RESULTS

4.1. Activity Pattern

African jacana were observed engaged in daily activities of feeding, scanning, flying, preening, resting, and showing other antagonistic activities. The recorded data indicated variation in day time duration among the most commonly observed activities in the same season and among seasons. Feeding activity comprised highest (40.1%) followed by scanning (19.6%), flying (16.5%), resting (11.6%), preening (9.7%) and other (2.5%) during the wet season (Fig. 4).

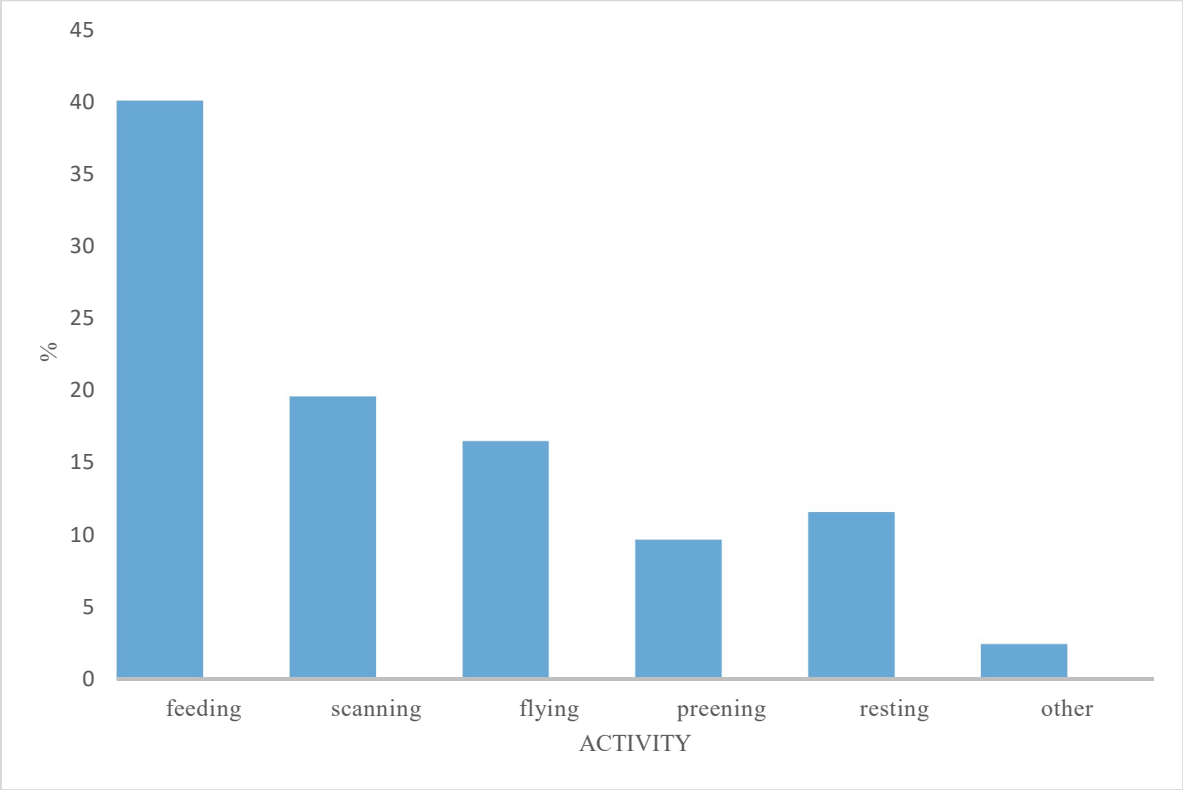

Figure 4. Activity patterns of African jacanas during the wet season

During the dry season, feeding activity (45.6%) was the highest again followed by scanning (19.7%), flying (15.2%), resting (9.2%), preening (7.9%) and other (2.3%) (Fig. 5)

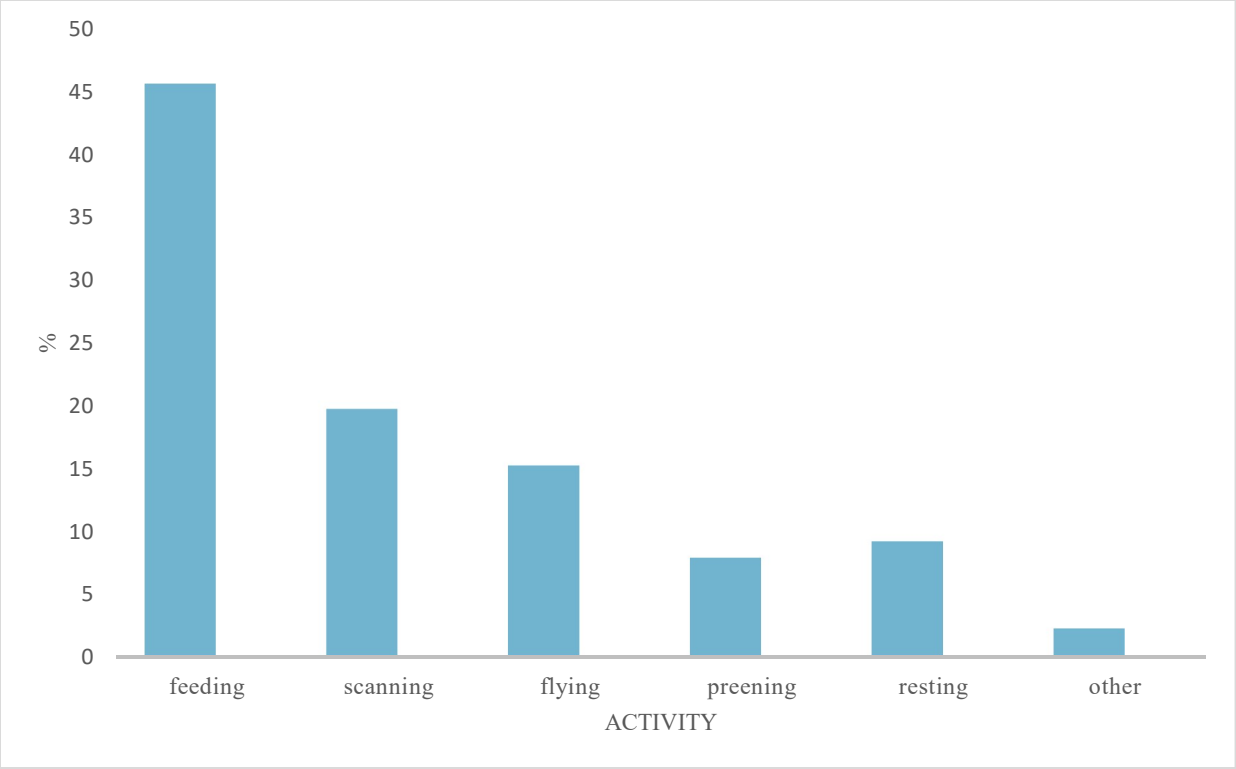

Figure 5. Activity patterns of African jacanas during dry season

The proportion of time allocated for different activity categories by the African jacana varied with season, for feeding ($P<0.05$) and flying ($P<0.05$) (Table 2).

Table 2. Mean proportion of time spent in different activities of African jacana during wet and dry seasons

	Proportion of time spent			
Activity	Wet season	Dry season	F	P
Feeding	95.8 ± 5.6	149.3 ± 8.9	25.574	**0.001**
Scanning	46.8 ± 4.2	57.4 ± 4.6	2.898	0.097
Flying	39.4 ± 2.6	49.8 ± 2.6	7.801	**0.008**
Preening	23.2 ± 1.6	26 ± 1.7	1.486	0.230
Resting	29.3 ± 3.1	30 ± 3.1	0.042	0.839
Others	5.9 ± 0.6	7.5 ± 0.8	2.232	0.143

Apart from seasonality, the mean proportion of time allocated to different activities varied with the time of the day. During both seasons, feeding was the predominant activity in the morning and late afternoon.

As compared to other activities, feeding and scanning for food were the two key activities hence a post hoc Tukey HSD pair-wise comparison for mean feeding and searching rates is conduct.

During the wet season, there was a significant difference in the mean rates for feeding ($F_{0.05, 2, 118} = 11.07$, $p < 0.05$) with rates being significantly higher in the morning than mid-day, significantly lower during mid-day than late afternoon and significantly higher in the morning than late afternoon (post hoc Tukey HSD, $p < 0.05$).

There was a significant difference in mean scanning rates ($F_{0.05, 2, 118} = 5.77$, $p < 0.05$) with rates for morning significantly higher than mid-day and late afternoon (Tukey HSD, $p < 0.05$). There was

significant difference in the mean rates for resting ($F_{0.05,2,118}= 6.38$, $p < 0.05$). However, there was no significant difference in the mean rates for preening ($F_{0.05, 2, 118}= 6.64$, $p > 0.05$) and other behaviour ($F_{0.05, 2, 118}= 0.89$, $p > 0.05$) for morning, mid-day and late afternoon.

For the dry season, the highest amount of time spent in the morning and evening was allocated to feeding. A one-way ANOVA test confirmed that there was significance difference in rates for feeding ($F_{0.05, 118} = 15.24$, $P < 0.05$) for the three time period blocks. The mean feeding rates were significantly higher in the morning than late afternoon (Post hoc Tukey HSD, $p < 0.05$). There was significant difference in mean rates for scanning ($F_{0.05, 118}= 6.9$, $p < 0.05$), flying ($F_{0.05, 118}= 5.03$, $p< 0.05$), resting ($F_{0.05, 118}=4.33$, $p < 0.05$) during the different periods. However, there was no significant difference in mean rates for preening ($F_{0.05, 118}=1.13$, $p > 0.05$) and other behavior ($F_{0.05, 118}=0.12$, $p > 0.05$) (Table 3)

Table 3. Percentage Activity during different time slots of the day

Activity	Time slots (hour)					
	6:00-9:00 (morning)		12:00-1:00 (mid-day)		4:00-6:00 (late afternoon)	
	Wet	Dry	Wet	Dry	Wet	Dry
Feeding	34	36.5	18.8	19	31.1	33
Scanning	22.6	24.5	15.3	13.1	21	21.7
Flying	14.9	18	15.2	11.7	15.8	17.7
Preening	17	12.6	17.3	21.4	20.5	15.8
Resting	9.8	6.2	31.1	31.7	9.5	9.9
Others	1.5	2.2	1.9	3	2	1.9

4.2. Foraging behaviour

African jacanas were observed collecting insects and seed from the lily leaf, worms and snails from shore line muddy area and occasionally in the substrata (ground) collecting insect, seed and other invertebrates. During the wet season, they were observed feeding on the lily leaf and in the muddy area. However, the frequency of occurrence in those microhabitats differ significantly (x^2=158.05, df =3, p <0.005). Fifty one percent of African jacana foraged on lily leaf, 25 % on *paspalidium germinatum* species, 18 % in muddy area and 6 % in the substrata (Fig. 6).

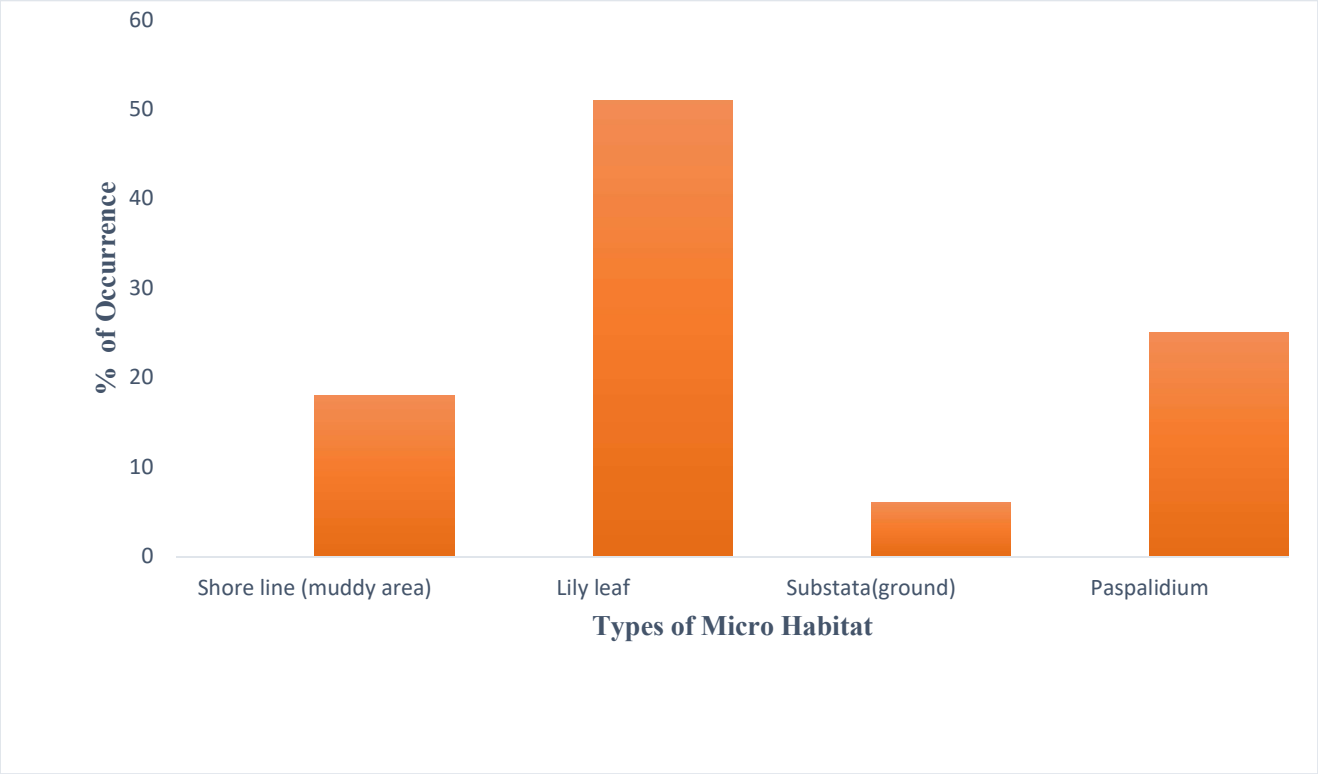

Figure 6. Foraging habitat preference of African jacana during the wet season

During the dry season, they use the lily leaf (56 %) and *paspalidium germinatum* species (30 %) as main foraging microhabitat and occasionally they were observed searching for food in shoreline and in the substrata (Fig. 7).

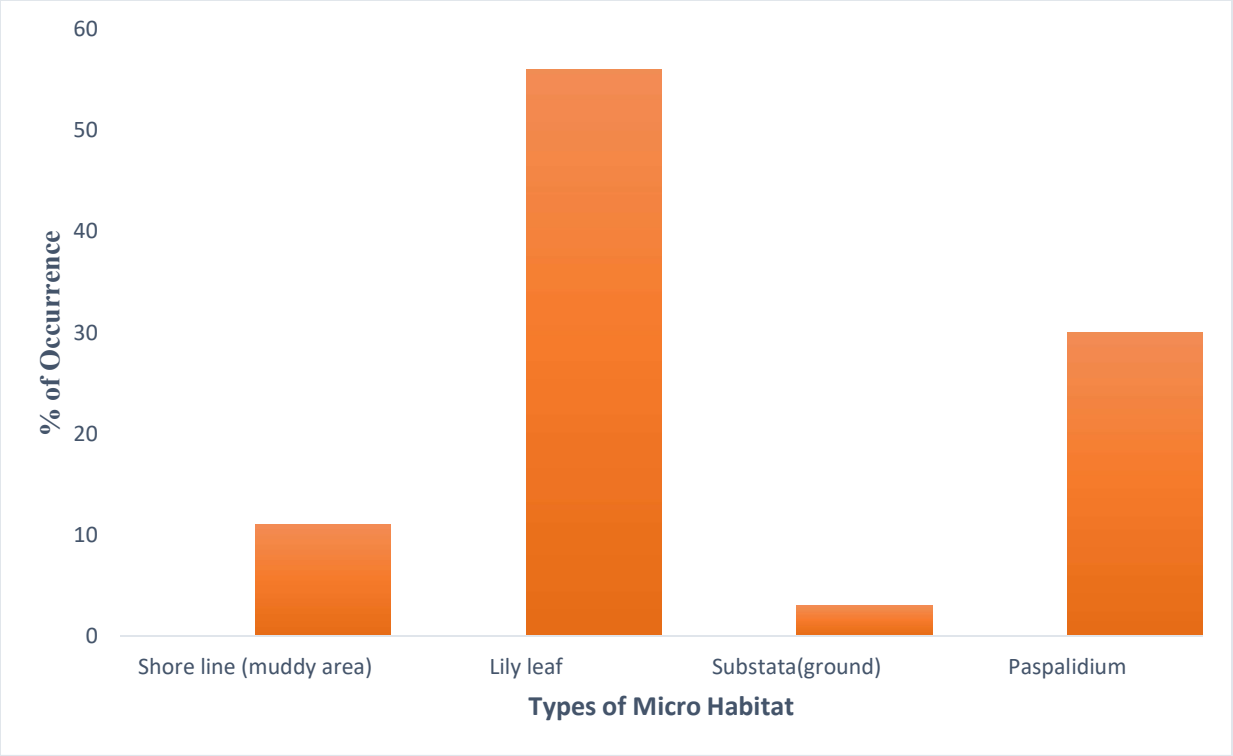

Figure 7. Foraging habitat preference of African jacana during the dry season

During foraging, African jacana walked and continuously probed the mud and lily leaf lowering the head down to filter out prey materials. They forcefully peck the bud of lily leaf which is unusual foraging strategy of the bird.

The diet of African jacana in percentage frequency consisted of insect (63.7%), worms (16.2%), larvae (5.4%), snails (5%), seed (3.7%) and other (6%) during the wet season. During the dry season, 55.6% of their diet consisted of insect, 12.2% worms, 8.2% larvae, 7.2% snails, 6.5% seed and 10.3% other. There was significant difference in the type of food consumed by African jacana during the wet ($F_{1\ 39} = 7.86$, $P < 0.05$) and dry seasons ($F_{1\ 39} = 3.11$, $P < 0.05$). However, there was no significance difference observed in the type of food consumed during the wet and dry seasons ($F_{1\ 39} = 1.48$, $P > 0.05$) (Fig. 8).

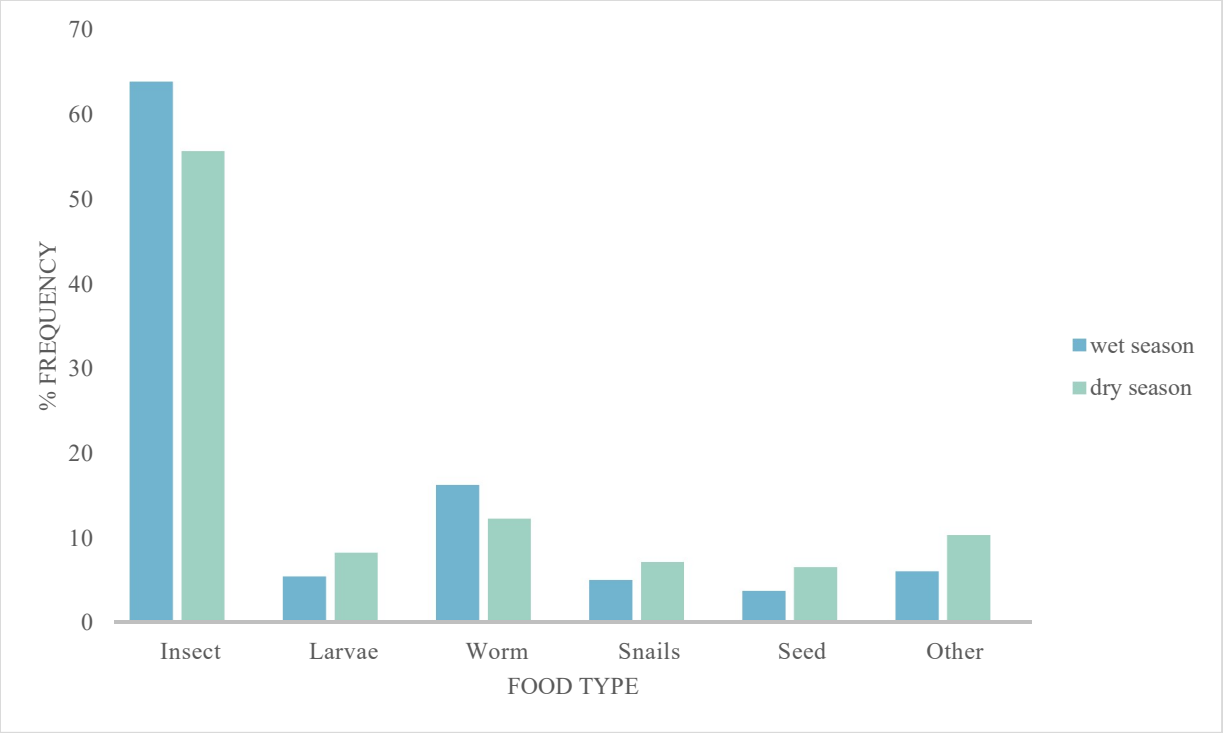

Figure 8. Diet of African jacana during the dry and wet seasons.

4.2.2. Food capture and handling techniques

African jacana employed active foraging while searching for food on the lily leaf, wetland and ground. The two capture techniques that were employed by the bird were picking (walking on the ground and picking prey) and run-picking (picking of food that was preceded by a short sprint). Picking was the most common food capture technique for both wet and dry seasons.

During the wet season, there was significant difference in the mean rates that African jacana employed picking (5.5 ± 0.25) as compared to run picking (0.02±0.02) (Fig. 9) (paired t-test; $t_{0.05,2,82}$=20.94, $p < 0.05$). During the dry season, there was significance difference in the mean rates that African jacanas employed picking (5.3±0.23) compared to the run-picking (0.1± 0.02) (Fig. 9) ($t_{0.05, 2.94}$= 23.35, $p < 0.05$).

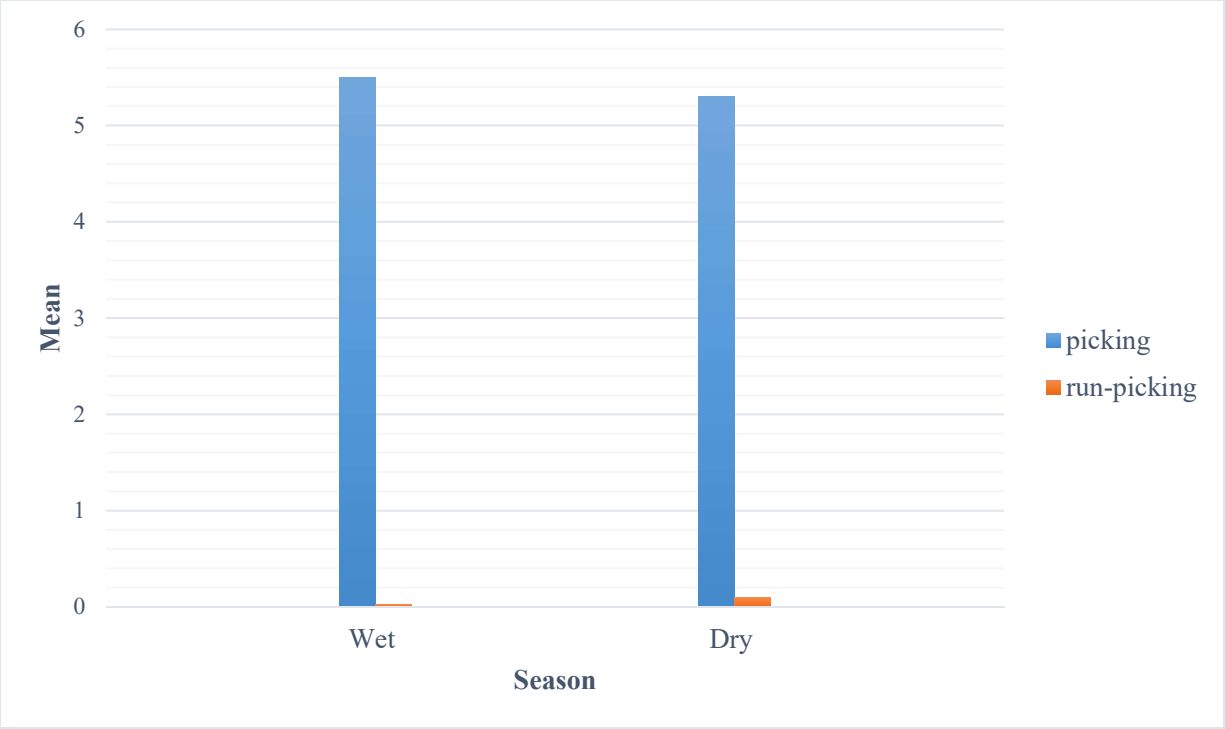

Figure 9. Mean ± SE of food capture techniques in African jacana

Tearing and gulping (cutting of food into smaller pieces followed by swallowing) and gulping (swallowing upon capture without manipulation other than food being held briefly using the bill) were the two food handling techniques used by African jacana. However, gulping was observed to be the most common food handling technique employed.

During the wet season, there was a significant difference in the mean rates that African jacana employed gulping compared to tearing and gulping ($t_{0.05,2,84}$=10.94, $p < 0.05$) (Fig. 10). Gulping was employed to handle food in 90.2 % of feeding bouts observed while tearing and gulping accounted for 9.8 % of feeding bouts.

For the dry season, there was a significant difference in the mean rates that African jacana employed gulping compared to tearing and gulping ($t_{0.05,2,96}$= 8.31, $p < 0.05$) (Fig. 10). Gulping was employed for 71.6 % of feeding bouts compared to tearing and gulping which accounted for

28.4 % of feeding bouts. The food items consumed by gulping were larvae, seed, insect while those by tearing and gulping were mostly worms, snails, seed, insect.

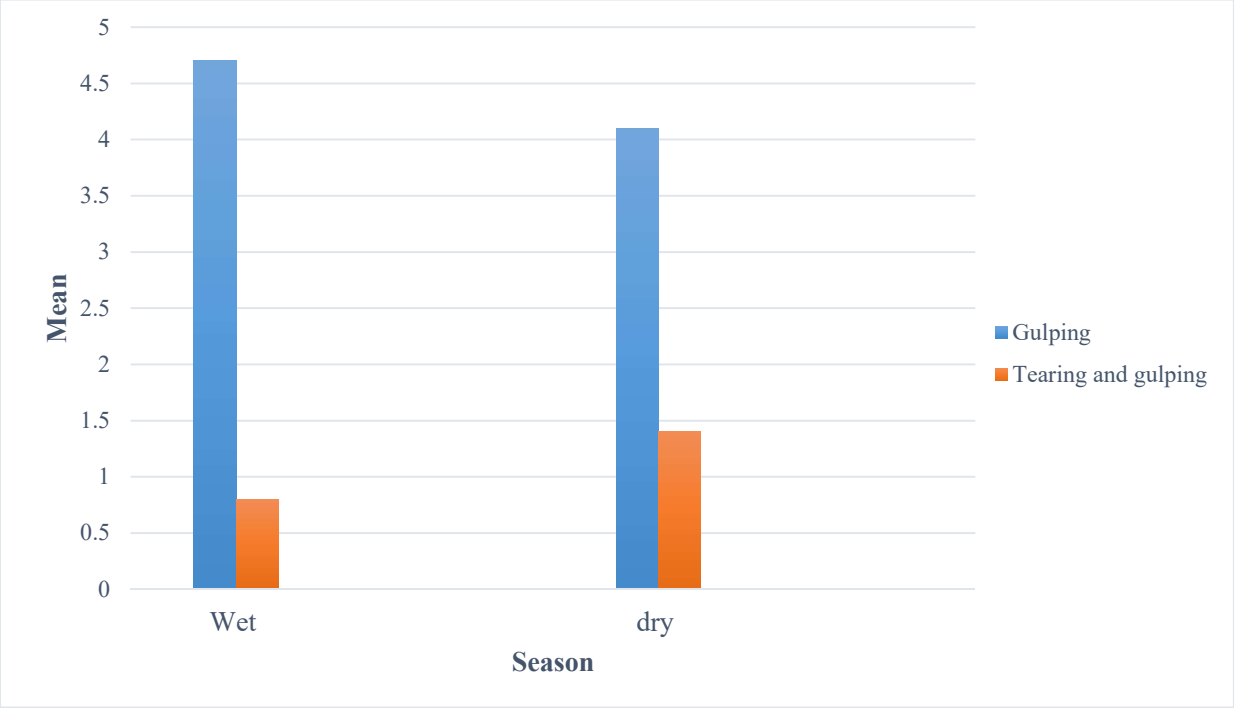

Figure 10. Mean ±SE of food handling technique in African jacana

5. DISCUSSION

Birds exhibit great flexibility in adjusting time budget to maintain their daily requirements (Das *et al*., 2011). Daily activity patterns of birds are influenced by several factors including weather, season and habitat (Bull, 1997), even though, activity patterns are likely to differ among species (Blake, 1992). African jacana change their activities during morning, mid-day and late afternoon periods.

Feeding was the most frequent activity of African jacana in both seasons because energy requirements are the key factor in the time allocated to feeding. This accounted for (40.1%) and (45.6%) during the wet and dry seasons, respectively. African jacana exhibited a typical biomodal feeding pattern: one peak during the morning and another peak during the late afternoon. Many species of birds are known to exhibit feeding maxima early in the morning and evening (Evers, 1994; Ramachandran, 1998; Rodway, 1998; Natarajan, 1999; Sivakumaran and Thiyagesan, 2003; Ali *et al*., 2010, Asokan *et al.,* 2010; Aissauoi *et al.,* 2011). The increasing feeding at the beginning of the day may be due to the start of their day-to-day activities, which have high energy requirements. The feeding peak at the end of the day may reflect the overnight energy requirement of the birds (Kelly, 1998). The differences recorded in seasonal feeding activity indicate that birds fed more often during the dry season and less in the wet season. In the study area, insect prey resources were abundant during the wet season (Asokan *et al.,* 2003). African jacana fed on a variety of insect groups, exclusively on order Diptera, Hymenoptera, Trichoptera, Lepidoptera, Odonata, Coleoptera (Bonkewitzz, 1997). Feeding activity was great on lily leaf because the insect prey spectrum is wide.

Scanning was the second main diurnal activity for African jacana. Scanning/searching activity was higher during the dry season and was lower in the wet season. This difference may be due to rainfall during this period, all the habitats were generally wet, which can affect the insect prey distribution. During the dry season, the dry habitat might force African jacanas to devote more time to scanning, while the reverse might be true during the wet season. The amount of time spent to scanning among time blocks and habitats may be inversely correlated to the insect availability. When insects are abundant, the birds spend less time on scanning; when insects are in short supply, the reverse is true (Ali *et al.,* 2010).

In general, the peaks in the flying activity were simiar to the peaks in feeding activity in time blocks and habitat but in seasons, flying activity was higher during the wet than the dry seasons. Generally, flight occurs due to movement from one location to another. Disturbances such as human activities and inter-and intra-specific completion are the primary causes of flight activity among African jacana.

Resting is a major midday activity of African jacana. They typically rest on *Paspalidium germinatum* species. The birds take a rest when the temperature reaches its daily maximum (e.g. 12:00-1:00 pm); subsequently, they slowly restart their activities. Tamisier (1976) suggested that the increase in resting during mid-day was a mechanism to minimize the heat load on a bird subject to high environmental temperatures. Previous studies on the activity patterns of the birds (Martinez, 2000; Asokan *et al.,* 2010; Abrham Megaze and Afework Bekele, 2013; Wlodarczyk, 2017) have revealed similar patterns of resting during the mid-day.

Preening occupied a small portion of the time budget and was usually performed in the early morning and late evening. The wings, breast and back were the body parts most often preened by African jacana, followed by the neck, rump and feet. The most frequent comfort activities were

bill scratching, feather shaking and wing flapping. Many bird species have been recorded spending time on these activities (Muzaffar, 2004; Ali *et al*., 2010; Asokan *et al*., 2010). The heighest preening was recorded during the wet season, as they need to preen their feather after a heavy shower. The females of African jacana were found to preen after copulation to rearrange their feather. Similar finding was observed in bronze-winged jacana (Joarder, 1997; Akhatar *et al*., 2009).

The study confirmed that African jacana is omnivorous and relies on animal food (insect prey) and plant diet (seed). These birds were considered to feed primarily on insects in orders Orthopetra, Coleopetera, Hymenopetra (Mwansat and Tushak, 2011; Okolie et al., 2015). The majority of birds rely on insect diet whose nutritional value is considered adequate to its rich and easily digestable fat and proteins (Okolie et al., 2015). In addition, insect food provides birds with essential elements of growth such as phosphorous, protein, non –chitin carbohydrates, lipids, vitamins and minerals (Klasing, 2000). These factors are likely to play a role in the preference of insect diet by African jacana.

The result of this study revealed that compared to the different diet, the largest proportion of African jacana comprised of insect diet (63.7% during wet season and 55.6% during the dry season). High feeding frequency on insect and worms was observed during the wet season. This was due to the growth of different vegetation and a variety of insects immediately following the rainfall providing more food during the wet season. Foraging habitat preference of African jacana during both seasons was on the lily leaf. This was due to the food abundance is greater than other micro-habitats as reported by Bonkewitzz (1997). Unusual feeding strategy was recorded during the dry season consuming bulbs of *Nymphaea lotus*. The method of feeding was concentrate

pecking at only one point, thus enlarging the hole through which the bird eats only the starchy part of the bulb (Bonkewitzz, 1997).

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The study provided key knowledge on activity pattern and feeding behaviour of African jacana, 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 pattern and feeding behaviour of the African jacana.

African jacana spent most of the time budget on feeding in both seasons. For the two observation periods of the day (morning and evening), feeding and scanning were the two dominant activites of the time budget. This supports the bimodal pattern of avian feeding where there is morning feeding and second peak late in the day.

African jacanas predominantly consume insects. The bird diet is supplemented by seeds, snails, larva and worms. Food abundance and availability is an important factor that influence the foraging behaviour of African jacana, hence wetland and lily leaf habitats are suitable habitats that provide for insect prey species and supplementary worm , seed and other diet for the bird. As a result, African jacana may have adapted to feeding largely on abundant insect species present on the lily leaf compared to wetland adjacent to ground habitat.

Thus, scientific study of activity pattern and feeding behaviour of birds has great importance, to understand the relationship of season and time of the day factor on the activity pattern and feeding behaviour of birds.

6.2. Recommendations

- Freshwater habitats including wetlands are becoming increasingly influenced by anthropogenic effect at a rapid rate hence resulting to huge loss of biodiversity and loss of habitats for avian species. The study confirmed that these habitats are very critical for conservation of wetland avian species, hence need to be protected from alteration through anthropogenic activities. There is need for the findings of this study to be integrated in a compressive wetland bird management plan of Hawassa Lake to minimize human activities.
- Since the results of this study relied on data collected from one study area (Hawassa Lake) over a period of two months, 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 bird and facilitate conservation measure.
- Deeper insight into the diet and feeding behaviour of the African jacana will require longer-term studies on the species. This may include use of stomach content analysis, fecal sample analysis, use of stable isotopes/mercury concentrations and next-generation sequencing (NGS). This will provide better understanding of dietary habitats and guide development of effective conservation strategies for the species and other wetland species.
- In the present study, it did not examine the effect of age and sex on the activity of African jacana, despite the fact that differences in activity exist among age and sex classes, there should be future studies to clarify the differences in activity among the age and sex classes of African jacana.

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