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Diurnal activity patterns, habitat use and foraging habits of Egyptian goose (*Alopochena egyptiacus* Linnaeus, 1766) in the Boyo wetland, southern Ethiopia

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ABSTRACT: Egyptian goose (*Alopochena egyptiacus*) is a resident bird species in Africa South of the Sahara occurring throughout the entire Nile Valley. Despite the wide distribution, the available information on its behavioral ecology is limited in Ethiopia. A study on the activity patterns, habitat use and foraging habits of Egyptian goose was carried out in and around Boyo wetland, Ethiopia, during the dry and wet seasons. Scan sampling method was used to study the activity patterns and habitat use of Egyptian goose in grassland, mudflat and shallow water habitats of the wetland. The feeding behavior of Egyptian goose was also observed in the surrounding farmland habitats using scan sampling method. Generally, Egyptian geese spent most of their time resting (39.81%) followed by foraging (32.64%). They spent 10.43% of their time in comfort movement preening or stretching. The rest of their time was allocated for locomotion (6.63%), vigilance (5.75%), and social behavior (1.59%), and other activities (2.86%). Most of the birds were engaged in foraging activity in the morning (07:00-9:00 h) and afternoon (16:00 - 18:00 h) hours both during the wet and dry seasons. About 39% of Egyptian geese were scanned in mudflat, 31.5% in grassland, and 30.05% in shallow water habitats engaged in different activities. Most individuals used the grassland habitat for foraging during the dry (59.5%) and wet (74%) seasons, while they used shallow water and mudflat habitats for resting both during the wet and dry seasons seasons. The birds were observed foraging mainly grass during the dry (93.62%) and wet (59.52%) seasons. The Egyptian geese show diurnal activity pattern with feeding peaks in early morning and late afternoon hours as is observed in many other avian taxa. The Boyo wetland is also as an important foraging ground for this species and other birds in the area. Further ecological studies on the species and impact of human activities on the Boyo wetland should be conducted for the conservation of the avifauna.

Keywords/phrases: Activity patterns, Boyo wetland, Egyptian geese, resident birds, scan sampling

INTRODUCTION

Egyptian goose *Alopochena egyptiaca* is a large (61-75cm long) and distinctively plumaged bird in the family Anatidae. These birds are monomorphic but females are slighty smaller in size than males. Egyptian goose is classified as "Least Concern", under the IUCN Red List criteria (BirdLife International, 2018). This species is one of the birds that had been raised in Egypt by the ancient Egyptians for for its beautiful plumage used for decoration in palaces and temples (Makram, 2018). The adult plumage is predominantly grayish on the head, neck, breast, under parts, flanks, and back, with darker, chocolate brown tones around eyes, nape, upper wing coverts, and with an irregular blotch on the lower breast. The primaries, tail feathers and rump are black, while the secondaries are iridescent green and the upper wing coverts are white except for a narrow black bar extending across the front of the greater secondary coverts (Johnsgard, 1978). Bill, legs, and feet are pink (Mackworth-Praed and Grant, 1980; Redman *et al*., 2009). The youngs on the other hand are dull with a gray shade on their forewings. Their crown and neck are darker and they have yellowish legs and beak.

Egyptian goose is one of the non-native waterfowl species in its native range in Africa, particularly South of the sub-Sahara with a population greater than 500,000 individuals (Davies, 2005; Banks *et al*., 2008). In addition to its native populations, there are successfully established populations in Europe and are considered one of the most rapidly spreading

invasive species (Gyimesi and Lensink, 2012). In North America, they occur in Florida, Texas and California, among other regions (Callaghan and Brooks, 2017). Egyptian goose show no regular migration, but make irregular movements up to 1000 km in response to changes in water and availability of food and presence of breeding ground (Oatley and Prŷs-Jones, 1985).

Egyptian geese are primarily herbivores and infrequently insectivores (Maclean,1988). However, there are reports where Egyptian geese cause damage to crops and agricultural lands, resulting in extensive economic losses (Mangnall and Crowe, 2002; Atkins, 2015) and their rapid population growth has led to an increase in the number of conflicts with people (Mangnall and Crowe, 2002; Stephen, 2008). However, limited information is available on the ecology and its diurnal activity patterns (Callaghan and Brooks, 2016)

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). In addition, knowledge on habitat use and foraging ecology of wetland birds has become fundamental in providing an understanding of the ways in which species in a habitat partition their resources (Schulze *et al*., 2000).

Egyptian goose is mostly dependent on wetland ecosystem (Brinson and Malvárez, 2002; Mitsch and Hernandez, 2013). In Ethiopia, Egyptian goose occurs across large areas; in or near by open country wetlands, meadows and grasslands of which Boyo wetland is one. Boyo wetland is one of the Important Bird Areas in Southern Ethiopia that supports different water birds including the globally threatened species, the wattled crane. Other bird species occurring in the this wetland includes black crown crane (*Balearica pavonina*) , squacco heron (*Ardeola ralloides*), cattle egret (*Bubulcus ibis*), yellow-billed egret (*Ardea brachyrhyncha)*, yellow billed stork (*Mycteria ibis*), glossy ibis (*Plegadis falcinellus*), sacred ibis (*Threskiornis aethiopicus*), spur winged goose (*Plectropterus gambensis*), and others (EWNHS, 1996). Despite the different bird species it supports, the wetland is threatened by expansion of range and farmlands that cleared the tree and grass cover causing major siltation and a decreas in the wetland water depth. Settlement and introduction of exotic tree species has further aggravated the wetland deterioration. High disturbance of birds by human and livestock is also reported (EWNHS, 1996).

Egyptian goose in its native range has a population greater than 500,000 individuals and increasing rapidly in numbers; i.e., more than 10% increase per year on average. In addition, populations in Europe are estimated at around 10.000 breeding pairs making them one of the most rapidly spreading invasive species (Banks *et al*., 2008). Their rapid population growth has led to an increase in the number of conflicts with people and human related activities, particularly within urban and sub-urban landscapes (Mangnall and Crowe, 2002; Stephen, 2008)

Application and implementation of any conservation measure towards a species or the habitat it depends on a scientific study of the ecological requirements of the target species and its habitat (Dugan, 1990). Egyptian geese are the dominant species in the study area being present throughout the year in large numbers. Hence, this study was aimed to investigating the activity patterns, habitat use and feeding habits of Egyptian goose in Boyo wetland, Southern Ethiopia.

METHODS

Description of the study area

Boyo wetland is located in Southern Nations Nationalities and Peoples Regional (SNNPR) State of Ethiopia about 300 km away from Addis Ababa, the capital city of Ethiopia. It is located in the Central Rift Valley area of Ethiopia between 07°28'-07°32'N Latitudes and 38°00'-38°40'E Longitudes (Fig. 1) (EWNHS, 1996). The Central Rift Valley area of Ethiopia consist of a chain of lakes, streams and wetlands with unique hydrological and ecological characteristics. The landscapes and ecosystems comprise extensive biodiversity-rich wetlands, which support a wide variety of endemic birds and other wildlife (Jansen *et al*.,

2007). Altitudinal ranges of the wetland vary from 1850 to 1900 m a.s.l. It is a swampy fresh water wetland . Climate in Boyo wetland is generally characterized by warm, wet summers (from June to September) and dry, cold and windy winter (December to March). The mean monthly rainfall of the area ranges from 9 mm in December to 195 mm in July. Maximum temperature of the area reaches 27.4°C during the warmest month of April and minimum in the coldest month of December (13.6 ^{o}C). As a result, the area is characterized as a semi-arid climate (EWNHS, 1996).

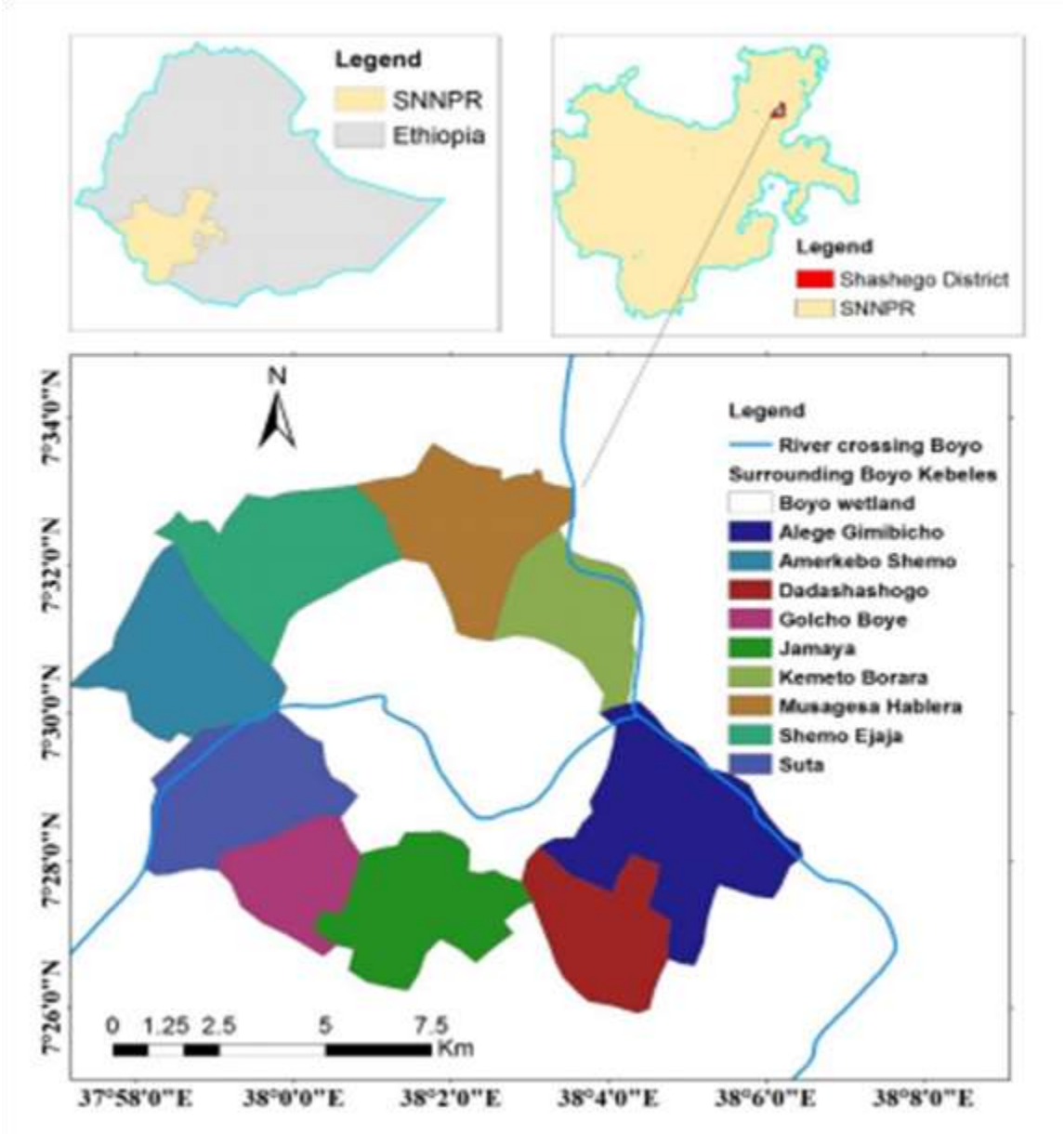

Figure 1. Map of Boyo wetland and surrounding Kebeles.

Data collection

Ecological studies on the diurnal activity patterns, habitat use and foraging behavior of Egyptian goose in Boyo wetland was carried out during the dry (December 2017 to May 2018) and wet (June to November 2018) seasons. Data were collected for a total of 33 days, 15 days during the wet season and 18 days during the dry season. Activity pattern and habitat use data were collected for 21 days and foraging habits for 12 days during the wet and dry seasons.Observation was made under good weather conditions with the aid of binoculars and/or naked eyes.

Activity patterns

The diurnal activity patterns of Egyptian goose were collected during both wet and dry seasons. When flocks, pairs or individuals of Egyptian geese were located, instantaneous scan sampling was carried out (Altmann, 1974; Sutherland, 2004) to collect the daily activity time budget of the species. This method provides an overall estimate of proportions of an individual's engagement in different behaviors (Webb *et al.*, 2011) and categorizing its major activities. Individuals were scanned or observed for five minutes, during which instantaneous behavioral observations were recorded at 15minute intervals (Döpfner *et al.*, 2009; Chudzinska *et al.*, 2013). The observations were made from early morning to late evening dividing the day into three time slots; morning (7:00-9:00 hrs), mid-day (11:00-13:00 hrs), and afternoon (16:00-18:00 hrs). Seven major behavioral activities of the Egyptian geese were distinguished: foraging, resting, comfort movement, locomotion, vigilance, social behavior and other activities. Foraging behavior refers to searching for food while walking with lowered head or head down, picking food items and ingesting (Jónsson and Afton, 2006; Döpfner*et al.*, 2009; Webb *et al.*, 2011). Resting behavior refers to a goose pausing, sleeping or loafing. Locomotion includes flying, swimming or walking while raising the head, running, flight and flapping. Comfort movements refer to cleaning or preening as well as muscle stretching. Vigilance or alert behavior refers to scanning or observing the surroundings area by raising its head upward or neck extended (Döpfner *et al.*, 2009). Social behavior refers to behaviors of aggression such as chasing, pecking or biting and courtship. Vocalizing, bathing and drinking were grouped as other activities (Webb *et al.*, 2011).Behavioral activities were recorded whenever more than one behavioral state occurred at the same time, the more frequent one performed by the majority of the individuals was taken (Edroma and Jumbe, 1983).

Habitat use

Habitat utilization of Egyptian geese was recorded in the grassland, mudflat and shallow water habitats of Boyo wetland using scan sampling method during which the activities of the birds within five minutes were recorded for each habitat. During the scan sampling, the number of birds in each habitat types and the activities they were engaged were recorded to investigate how the species utilize its surroundings to increase the likelihood of its odds of survival.

Foraging habit

To collect data about the diet composition of Egyptian geese, repeated observations were made. 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. All observations on diet studies were carried out between the hours of 06:30-11:30 hrs in the morning, and 14:30-18:00 hrs in the afternoon. These time periods were selected as it is found to be active foraging times of the species (Bibby *et al.,* 1992). When the bird was located it was first observed for 10 seconds without recording any data. This time period minimized the likelihood of recording only the conspicuous behavior, and also ensured that the bird resumed normal activity in the presence of the observer. Observation began as soon as the focal bird began foraging. 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). 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). During the observation, the type of food items consumed in each minute was recorded.

Data analysis

Data were analyzed by using SPSS version 20 computer software programme (SPSS inc, IL, USA) and Microsoft Excel. Chi square test was used to compare the different behavioral activities in the three time blocks. Mann Whitney U-test was used to compare data for wet and dry season activities and foraged food items. Diurnal activities among the different habitat types and seasons were compared using two-way ANOVA.

RESULTS

Diurnal activity patterns

Egyptian geese were occurred in grassland (31.5%), mudflat (38.45%) and shallow water

(30.05%) habitats. Overall, majority of the individuals spent their time on resting (39.81%), followed by foraging (32.64%), comfort movement (10.63%), locomotion (6.65%), vigilance (5.78%), social behavior (1.59%), and other activities (2.89%).

During the dry season, Egyptian geese spent most of its time foraging in the afternoon hours (16:00 - 18:00 h) followed by morning (07:00-9:00 h) and mid-day hours (11:00-13:00). Resting in Egyptian gees was the highest during mid-day hours (11:00-13:00 h), and they were also seen resting in the morning (07:00-9:00 h) (Fig.2a).

Time spent for foraging, comfort movement, vigilance, locomotion activity, social and other activities showed no significant statistically difference with the time blocks of the day. However, time spent for resting showed a statistically significant difference with the time blocks of the day (x^2=10.738, df=2, P=0.005).

During the wet season, foraging activity peaked in the late afternoon (16:00 -18:00 h), followed by morning (07:00-9:00 h), and mid-day hours (11:00 - 13:00 h). Resting was higher during the mid-day (11:00 -13:00 h) and morning hours (07:00-9:00 h) (Fig. 2b).

Time spent for foraging (x^2= 6.049, df=2, P= 0.049), resting (x^2=14.102, df =2, P= 0.001) and other behavioral activities (x^2= 9.556, df=2, P= 0.008) showed a significant difference within the time blocks of the day.

A comparison of the seven different diurnal activities between dry and wet seasons at different time blocks showed no statistically significant difference ($p > 0.05$) for foraging, resting, comfort movement and vigilance. However, a statistically significant difference was observed in time spent for locomotion(U= 351.5, df =1, P= 0.001), social behavior (U= 350, df =1, P = 0.001) and other activities (U= 308.5, df = 1, P = 0.00), showing that relatively more time was spent during the dry season than the wet season.

Habitat utilization

Egyptian geese spent most of their time foraging in the grassland habitat followed by shallow water during the dry season. They mainly use the mudflats for resting followed by shallow water habitat (Fig. 3a).

There was statstically significant difference in habitat utilization for activities of foraging ($F_{(2, 33)} = 8.729$, p = 0.001), resting ($F_{(2,33)} = 7.318$, p = 0.002) and comfort movement ($F_{(2,33)} = 7.173$, p = 0.003) of Egyptian geese among the three habitat types. However, there was no statistically significant difference in activities of locomotion, vigilance, social behavior, and other behavioral activities in the three habitat types of the study area ($p > 0.05$).

During the wet season, most of the birds spent their time foraging in the grassland habitats followed by mudflats among the three habitats, and they used the shallow water for resting followed by mudflats habitat (Fig. 3b).

Habitat utilization of birds showed statistically significant variation among the three habitats during the wet season for foraging ($F_{(2,33)} = 11.914$, p = 0.000), resting ($F_{(2,33)} = 8.271$, p = 0.001), comfort movement ($F_{(2,33)} = 3.344$, p = 0.048) and vigilance ($F_{(2,33)} = 7.274$, p = 0.002). However, there was no statistically significant difference in time spent for locomotion, social behavior, and other behavioral activities among the three habitat types of the study area ($p > 0.05$).

Foraging habits

Egyptian geese in Boyo wetland were observed foraging on a wide variety of food items including grass, seeds, leaves, grain, crop seedlings, aquatic rhizomes and tubers, and insects, invertebrates.. During the dry season, Egyptian geese consumed grass (93.62%), followed by invertebrates (5.56%), leaves (0.55%), and seeds (0.27%). During the wet season, the highest percentage frequency of Egyptian geese diet constituted grass (59.52%) and invertebrates (40.5%) (Table 1). The percentage frequency of foraging on grass, seeds, leaves and invertebrates in the diet were not statistically different between seasons (U = 6, df =1, P= 0.564; U = 6, df =1, P= 0.317; U = 6, df =1, P= 0.317 and U = 8, df =1, P= 1.000), respectively.

In addition, Egyptian geese were observed foraging on harvested grains such as maize (*Zea mays*), sorghum (*Sorghum bicolor*), and wheat (*Triticum aestivum*) and also on unharvested teff (*Eragrostis tef*) and soybean (*Glycine max*) which are the major cultivated crops around Boyo wetlands.

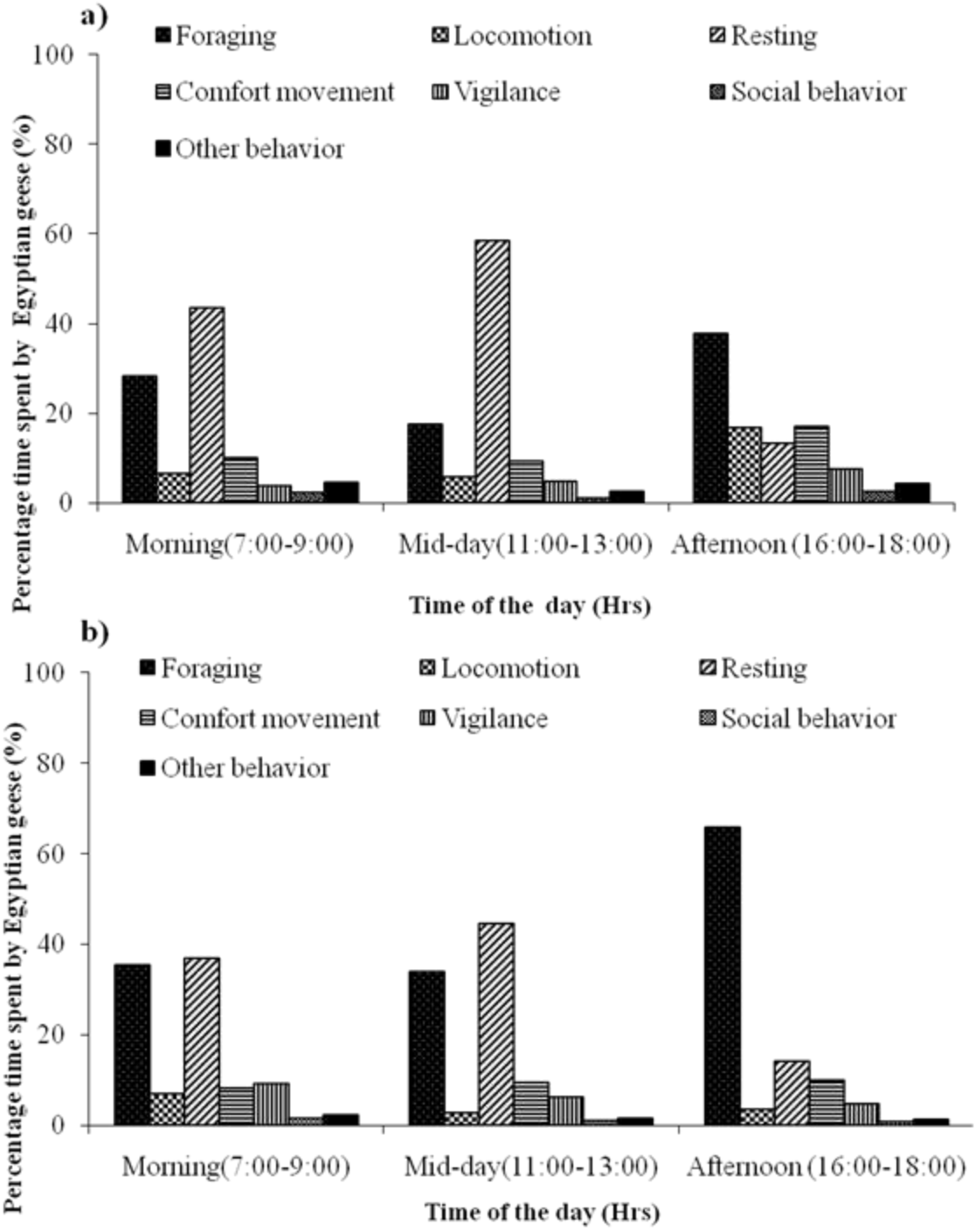

Figure 2. Percentage of time spent by Egyptian geese's diurnal activity in the different time blocks during the dry(a) and wet (b) seasons.

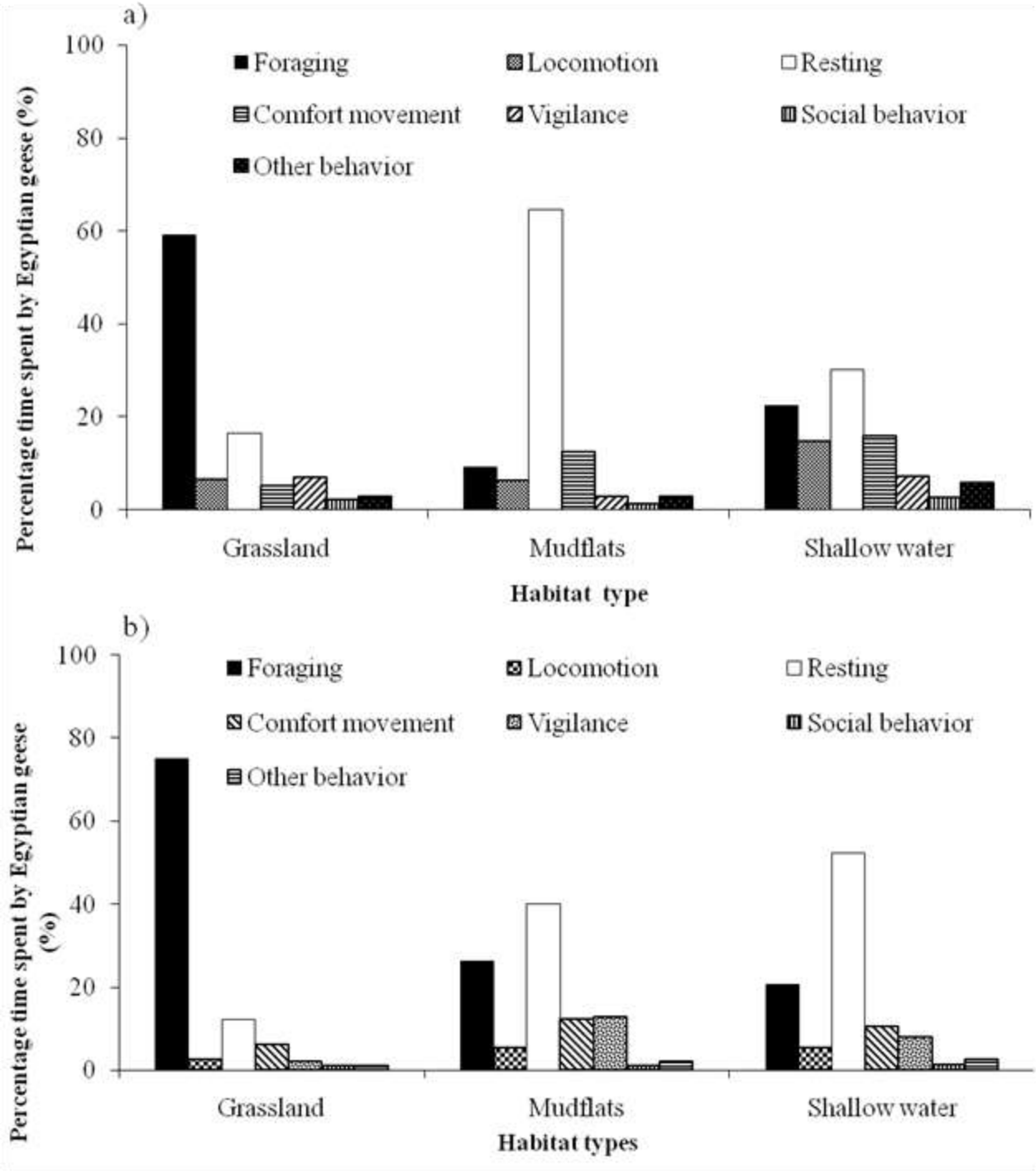

Figure 3. Percentage of time spent by Egyptian geese's in different activities and habitat types during a) dry and b) wet seasons.

Table 1. Percentage frequency of food items consumed by Egyptian geese during the dry and wet seasons.

Season	Foraging food items				
	Grass	Invertebrate	Seeds	Leaf	Total %
Dry	93.62%	5.56%	0.27%	0.55%	100%
Wet	59.52%	40.5%	0%	0%	100%
Mean	76.56%	23.03%	0.135%	0.275%	100%

DISCUSSION

Most of the Egyptian geese were observed in mudflat habitats. This habitat may provide a safe ground for the birds from human disturbance. They can also move to grassland habitat for foraging with minimal energy expenditure to move between habitats. Birds exhibit great flexibility in adjusting time budget to maintain their daily ecological requirements (Das *et al*., 2011) that could be influenced by several factors such as weather, season and habitat (Bull, 1997). The overall diurnal activity patterns in Egyptian geese showed that most of the birds were observed resting, followed by foraging. Egyptian geese spent maximum time forging early in the morning and in the afternoon hours. However, Egyptian gees are also reported foraging at night (Johnsgard, 2010) and this might be the reason for lower percentage of time spent for foraging compared to resting during the day in this study. In addition, human disturbance due to agricultural activities in the Boyo wetlands might hinder the birds from following their normal diurnal activities and could have extended foraging at night that requires further investigation.

During the dry season, time spent by Egyptian geese for foraging did not show any significant difference among the different time blocks; they mainly foraged in the afternoon hours (16:00 - 18:00 h) but they also foraged in the morning and mid day hours. This might be due to the limitation of the availability of food resources during the dry season that requires the birds to spend more time forging to fulfill their energy requirements. In addition, dry season provides favorable weather condition to forage uninterrupted. Similar observation was recorded in wetland birds such as African Jacana in Lake Hawassa (Kidist Amha and Bezawork Afework, 2018). However, during the wet season time spent foraging was the highest in the afternoon hours than the other time blocks. This might be due to the availability of enough forage and the bird's preference of safe foraging time with minimal human disturbance in the late afternoon hours. The feeding peak at the end of the day might also reflect the overnight energy requirement of birds (Kelly, 1998). Insect preys may also be abundant during the wet season compared to the dry season that might have contributed to the relatively shorter foraging duration by African jacana during the wet season as insects fulfill protein requirements of birds (Asokan *et al*., 2003).

Egyptian geese showed resting peak during mid-day both during in the wet and dry seasons. Many species of birds are known to exhibit maximum time for feeding early in the morning and in the late afternoon (Natarajan, 1991; Evers, 1994; Ramachandran, 1998; Rodway, 1998; Ali *et al*., 2010, Asokan*et al*., 2010; Aissauoi*et al*., 2011) with peak resting during the mid day, which is common among birds to pass over the high temperature. An increase in resting during midday helps birds minimize heat load during high environmental temperatures. Previous studies on the activity patterns of birds have revealed similar patterns of resting during the mid-day (Abrham Megaze and Afework Bekele, 2013; Wlodarczyk, 2017).

Habitat utilization of Egyptian geese in Boyo wetland showed that they used the grassland, mudflat and shallow water habitats differently for their activities. The grassland habitats was predominantly used for foraging both during the dry and wet seasons. As Egyptian geese are primarily herbivores feeding on grasslands (Tattan, 2004), this habitat may provide greater food abundance compared to other habitats. On the other hand, Egyptian geese were mainly observed using mudflats and shallow water for resting during the dry and wet seasons, respectively.

In the Boyo wetlands, Egyptian geese predominantly consumed grass both during the wet and dry seasons . However, they consumed invertebrates in high proportion during the wet season. High feeding frequency on insects during the wet season could be due to the growth of different vegetation that support insects, Moreover, the emergence of variety of insects immediately following the rainfall during the dry season ensuring insect abundance. Similar

observation was reported by Titan (2004) where Egyptian geese are primarily herbivores, feeding on grasslands at times far away from water bodies feeding on aquatic vegetation but also animal prey such as worms, insects, and frogs. In addition, harvested grains, such as maize (*Zea mays*), sorghum (*Sorghum bicolor*) and wheat (*Triticum aestivum*) and also unharvested teff (*Eragrostis tef*) and soybean (*Glycine max*) were foraged by the birds from surrounding farmlands of Boyo wetland. Similar observation was reported in South Africa where these birds are considered pests by farmers especially during the germination periods of the months of April-July and harvesting periods during October-December (Jancikova, 1996). Extensive economic losses caused by Egyptian geese due to damage to crops and agricultural lands were reported resulting in human-wildlife conflict in South Africa. But their ecologically important role in decreasing pest populations around lakes or fields was also noted (Mangnall and Crowe, 2002). Further investigation is required on their ecological importance and the extent of damage to agricultural products in the farmlands surrounding the Boyo wetland.

CONCLUSION

Boyo wetlands support a wide variety of bird species. The degradation of this wetland can have an adverse effect on waterfowl of the area. Egyptian goose is one of the wetland birds commonly observed in and around Boyo wetland. They actively forage in the grassland habitat both during the wet and dry seasons with peak resting during the mid day hours. Egyptian geese primarily feed on grass but a wide variety of insects were also consumed during the wet season where they are abundantly available following the rain. They were observed forging on seedlings of crops grown nearby the wetland.

The ongoing degradation of Boyo wetland caused by habitat destruction, heavy sedimentation, wetland canalization, settlment and overgrazing can aggravate the human-wildlife conflict through the shortage of food available for the Egyptian geese and other bird species in the area. When natural food sources are insufficient to meet their nutritional requirements, agricultural lands on the edge of wetlands become the new food sources for Egyptian geese and other birds creating conflict. Hence, immediate conservation intervention is required to maintain Boyo wetland, an Important Bird Area for the conservation of the Egyptian geese and their conspecifics.

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