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FORAGING BEHAVIOUR AND POPULATION STATUS OF THE WHITE-BREASTED CORMORANT (*PHALACROCORAX LUCIDUS*) IN LAKE HORA-ARSEDI, BISHOFTU, ETHIOPIA

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ABSTRACT: The present study was conducted at Lake Hora-Arsedi located in Bishoftu town, 47 km south of Addis Ababa. The aim was to investigate the dive duration, pause duration, perching height, foraging band and population status of the white-breasted cormorant (*Phalacrocorax lucidus*) in the study area. Two sites were selected to carry out the observations. Data were collected from January–December 2014 to include dry and wet seasons mainly based on direct observational methods. Focal observations were carried out on randomly selected foraging cormorants within the two systematically oriented observation sites. A single individual was observed for 20 minutes. Total population count was made at two roosting sites along the shoreline following roost count technique. Roost count was made 15 times at each season. The total number of population during wet and dry seasons was 23 ± 0 .4125 and 33 ± 0.43498. The mean dive duration at site 1 during the dry season was 22.32 ± 0.84 and 30.3 ± 0.75 seconds during the wet season. The mean dive duration at site 2 during the dry season was 25.76 ± 0.68 seconds and it was 39.25 ± 0.96 during the wet season. The mean dive duration at both sites showed significant variation between seasons ($P<0.05$). Dive duration and pause duration were significantly positively correlated in both sites during both seasons. Dive efficiency ranged from 1.67 to 2.26. Mean perching height ranged from 1.8 ± 0.15 to 2.3 ± 0.25 and the variation was not significant. Mean foraging band ranged from 11.56 ± 0.91 to 22 ± 1.2 m and the variation was significant between sites of the same season ($P<0.05$) but was insignificant between seasons of the same site ($P>0.05$).

Key words/phrases: Bishoftu, Dive duration, Foraging band, Great cormorant, Pause duration.

INTRODUCTION

White-breasted cormorant (*Phalacrocorax lucidus*) is a member of a cormorant family Phalacrocoracidae. They are one of the most widespread cormorant species found throughout Europe, Asia, Africa, Australia, and in northeastern coastal areas of North America (Johnsgard, 1993). White-breasted cormorants vary in size (84 to 90 cm in length and 2.6 to 3.7 kg in weight) (Hatch *et al*., 2000). They have a wing span ranging from 130 to

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160 cm. There is no colour or other major variation in appearance between sexes, but males are longer and heavier than females. In general, North American and Palearctic individuals are larger in size than Asian and African populations. The major morphological variations across the geographic range of the species are the size of white plumes on the head and neck, the colour of skin on the head, and the colour of the sheen on the black plumage (Hatch *et al*., 2000).

White-breasted cormorants commonly eat fish less than 20 cm in length and occasionally consume larger fish, up to 75 cm long or 1.5 kg in weight. Some crustaceans are also consumed rarely. Fish are taken mostly in shallow water less than 20 m deep. However, they are not specific to a certain dive depth. They are opportunistic hunters and are attracted to areas of high prey density. They demonstrate high variability of dive sites and dive depths depending on the availability of prey species (Boldreghini *et al*., 1997; Gremillet *et al*., 1998). They depend on their vision to dive in and chase fish under the water. They eat small fish under water and carry larger fishes to the surface to swallow. They forage in flocks or alone and such variation depends on region and among subspecies (BirdLife International, 2008).

During swimming under water, cormorants drag their wing and tightly fold close to their body. Feet propulsion is coordinated with tightly folded wings (Schmid *et al*., 1995). The shape of the body is properly fitted with their environment. This reduces the resistance force on the body (Baudinette and Gill, 1985).

Fishes constitute the main diet of the bird. The bird usually forages in a foraging band of 10-200 m from the shoreline of the sea and dive up to 82 seconds, although considerably less in freshwater. They typically forage by undertaking a series of dives from water surface interspersed with brief recovery periods or surface pauses (Cooper, 1986). Diving behaviour is controlled mainly by physiological constraints within a group. Larger species with a potentially larger capacity for oxygen storage, stay submerged longer than smaller ones (Cooper, 1986; Kooyman, 1989).

Solitary feeding is the most frequently used foraging strategy of white-breasted cormorant (Watanuki *et al*., 2004). Occasionally, small and large groups were reported to exploit the prey population (Bernstein and Maxson, 1982; Watanuki *et al*., 2004). Like other aquatic birds, cormorants can locate feeding flocks by observing the flight of other birds towards a feeding flock (Hoffman *et al*., 1981). This type of information transfer is called network foraging (Wittenburger and Hunt, 1985).

Activity pattern investigation for a species is an important input for species and habitat based conservation activities. Foraging activities such as dive duration, pause duration, perching behaviour and foraging band (distance from the shore) are vital ecological components of the species. A variety of environmental factors such as water depth, nature of the bottom and prey density are reported to affect the feeding performance of cormorants (Carbone and Houston, 1994).

Many researchers have conducted studies on the feeding behaviour of cormorant species. They include comparison of dive and rest times, comparison of dive times among different species and study of diving patterns (Cooper, 1986: Casaux, 2004). During foraging, they undertake a series of dives from the water surface interrupted with brief recovery periods or surface pauses (Cooper, 1986).

In Ethiopia, specifically in Lake Hora-Arsedi, ecological study has not been conducted to investigate the foraging activity and population status of white-breasted cormorant. Therefore, this study was aimed at investigating the population status, dive duration, pause duration, and perching and foraging attributes of the species.

MATERIALS AND METHODS

Study area

Lake Hora-Arsedi is a small (1.03 km^2) crater lake formed by volcanic activity in early Holocene (~7000 years ago) at an altitude of 1850 m a.s.l. (Mohr, 1961). It is a double crater with a maximum depth of 38 m (north crater) and 31 m (south crater) and a mean depth of 17.5 m. It is located in Bishoftu (Debre zeit) town about 47 km southeast of Addis Ababa (Fig. 1). Like all the other volcanic crater lakes in this area, Lake Hora-Arsedi is a closed system, surrounded by very steep and rocky hills and cliffs. The lake has both indigenous and exotic flora, terrestrial and aquatic fauna including a variety of birds (Betre Alemu, 2000). The region around the lake is characterized by moderate rainfall, around 850 mm per annum with high incidence of solar radiation and low relative humidity (Rippey and Wood, 1985). The region has two rainy seasons, the short rainy season from February to April and the long rainy season from June to September.

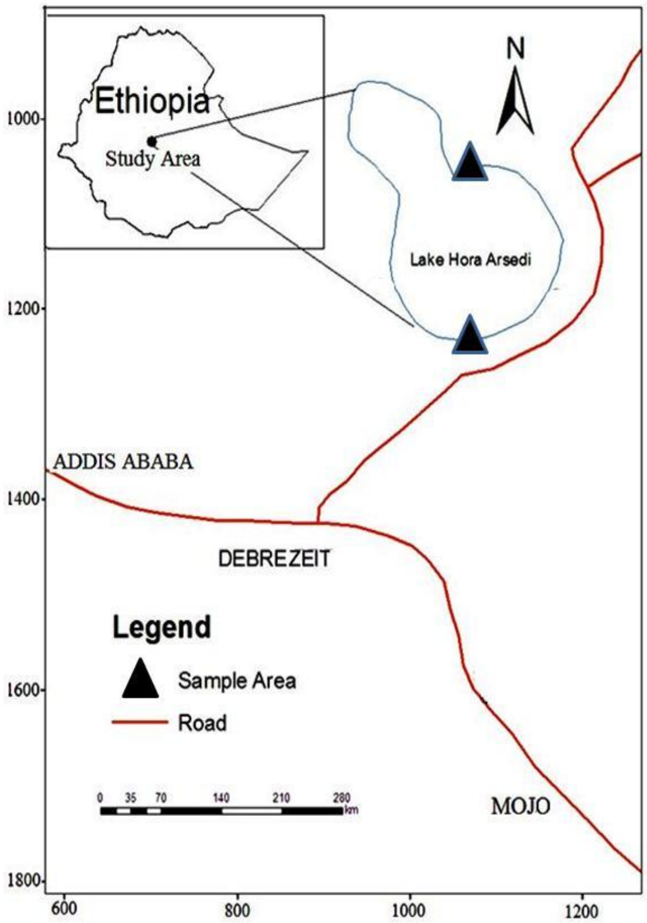

Fig. 1. Map of the study area (Modified from Mesele Yihune and Afework Bekele, 2010).

Sampling design

During preliminary survey, two sites were selected to carry out the observations. The sites were systematically selected based on the availability of birds, difference in water depth at foraging band and availability of perching sites on the shores. Water depth was measured at both sites using mechanical technique (rope with hanging metal). Site 1 (nearby Erecha cultural celebration site) has a depth of 3.5 m while the site near Mekoninoch Kibeb (site 2) has an average depth of 18 m. Both observation sites were situated along the eastern part of the lake. The eastern part of the lake is more open and preferred by the birds for foraging. Birds frequently visit and spend more time at this site. The western part of the lake is surrounded by dense vegetation with very steep slope which is inaccessible for observation and less preferred by the birds for foraging. The study was conducted from January to December 2014 to include both the dry and wet seasons.

Data collection and analyses

Data on foraging activities were collected in the morning from 6:30 to 11:00 a.m. and in the afternoon from 2:00 to 6:00 p.m., when most of the avian species are active (Williams and Arlott, 1980). Data were collected mainly based on direct observational method (Altmann, 1974). Wet season data were collected from February to September 2014 and dry season data were collected from October to December 2014. Focal animal observations were carried out on randomly selected foraging cormorants within the two systematically oriented observation sites. Each located bird was observed for 20 minutes. If the located bird went out of sight prior to the end of observation period, the result was discarded. Observations were made from convenient vantage points on the shore using a stopwatch and binoculars (8 x 40). The duration of a diving bout is taken as the time between submerging on the first dive and surfacing after the last dive. A dive cycle consisted of a single dive and surface pause. Diving efficiency is defined as the ratio between mean diving time and mean recovery period (Dewar, 1924). The distance from the shore to the foraging bird in the water was estimated and recorded to calculate the mean foraging band of the bird at both sites. The height of perching from the ground, the perching site (whether live tree, stone or cut tree) along the shoreline was recorded to compute the perching site preference and height at different sites. Total population count was made following roost count techniques at two identified roosting sites (Sutherland, 1996). Total count was made 15 times at each season to refine the precision.

Both descriptive and inferential statistics were employed to analyze the qualitative and quantitative data using SPSS version 20 software. Paired sample t-test was used to test the significance of seasonal population size difference of the species and to compare mean diving duration and pause duration between different sites of the same season and between seasons of the same site. Bivariate correlation was computed to calculate the correlation factor between diving duration and pause duration. The significance of correlation was tested.

RESULTS

Population count

The number of white-breasted cormorants counted during the wet and dry season was 23 ± 0.4125 and 33 ± 0.43498, respectively. The total number of individuals showed significant variation between seasons (P<0.05). The mean number of white-breasted cormorants counted during the dry season was significantly greater than the wet season. The population density was 23 individuals/km^2 for the wet season and 33 individuals/km^2 for the dry season.

Dive duration

At both the feeding sites, a total of 453 dive cycles and 15 diving bouts were recorded covering different times of the day.

The mean dive duration was significantly different between wet and dry seasons at both site 1 and site 2 (P<0.05). During the wet season, the mean dive duration was 30.3 ± 0.75 seconds at site 1 and 39.25 ± 0.96 seconds at site 2 while the dry season record showed a mean dive duration of 22.32 ± 0.84 and 25.76 ± 0.68 at site 1 and site 2, respectively (Fig. 2a).

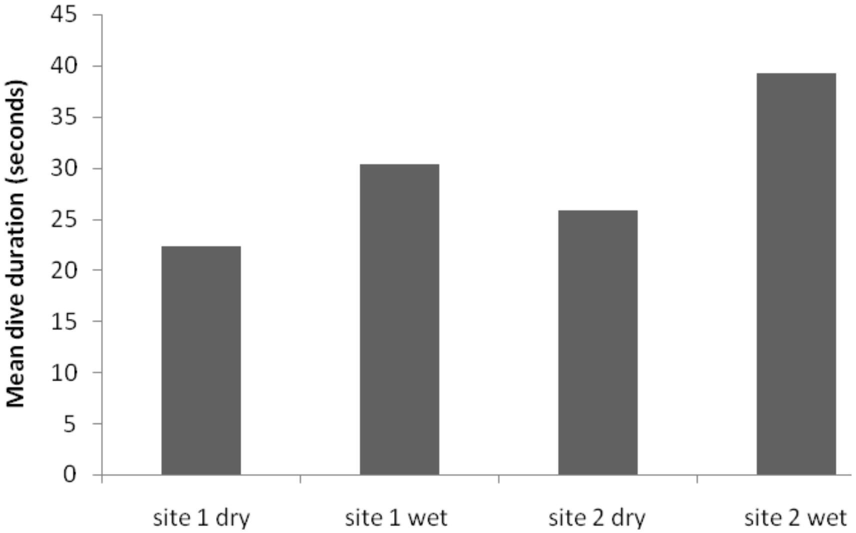

Fig. 2a. Mean dive duration at site 1 and site 2 during dry and wet seasons.

Pause duration

The mean pause duration was significantly different between wet and dry seasons at both site 1 and site 2 (P<0.05). During the wet season, the mean pause duration was 13.75 ± 0.38 seconds at site 1 and 17.33 ± 0.39 seconds at site 2 while the dry season record showed a mean pause duration of 11.97 ± 0.34875 and 15.40 ± 0.27 at site 1 and site 2, respectively (Fig. 2b).

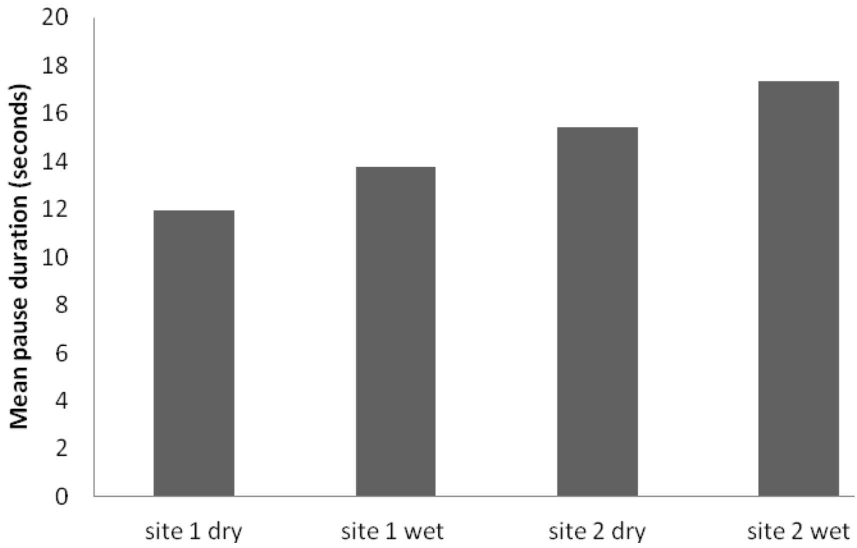

Fig. 2b. Mean pause duration at site 1 and site 2 during dry and wet seasons.

Dive efficiency ranged from 1.67 at site 2 during the dry season to 2.26 at site 1 during the wet season. During the wet and dry seasons in both sites (site 1 and site 2), there was a significant correlation between dive duration and pause duration (P<0.05).

Perching height

Mean perching height at site 1 during the dry season was 1.8 ± 0.15 m with minimum and maximum value of 1 and 3 m, respectively (Table 1). During the wet season, the mean value was 2.3 ± 0.25 m from the ground with a minimum of 1 and a maximum of 3.5 m. The variation for mean perching height at site 1 was not significant between wet and dry seasons (P>0.05).

Mean perching height at site 2 during the dry season was 2.2 ± 0.17 m with minimum and maximum value of 1.5 and 3.5 m, respectively (Table 1). During the wet season, the mean value was 2.16 ± 0.18 m from the ground with a minimum of 1.5 and a maximum of 4 m. The mean perching height at site 2 did not vary significantly between seasons (P>0.05).

Table 1. Mean perching height and foraging distance during dry and wet seasons at sites 1 and 2.

	Site 1		**Site 2**	
	Dry	**Wet**	**Dry**	**Wet**
Mean perching height (m)	1.8 ± 0.15	2.3 ± 0.25	2.2 ± 0.17	2.16 ± 0.18
Mean foraging distance (m)	22 ± 0.12	21.9 ± 1.18	11.88 ± 0.88	11.56 ± 0.91

Foraging band

Mean foraging band at site 1 during the dry season was 22 ± 0.12 m and ranged from a minimum of 10 m to a maximum of 30 m (Table 1). During the wet season, the mean value was 21.9 ± 1.18 and ranged from 9 to 31 m. The variation of mean foraging distance at site 2 was not significant (P>0.05) between seasons.

Mean foraging band at site 2 during the dry season was 11.88 ± 0.88 m and ranged from a minimum of 5 m to a maximum of 20 m. During the wet season, the mean value was 11.56 ± 0.91 and ranged from 2 to 31 m. The mean foraging band did not significantly vary between seasons at this site (P>0.05).

Mean foraging band between sites 1 and 2 during the dry season varied significantly (P<0.05). During the wet season, the mean foraging band between sites 1 and 2 also showed significant variation (P<0.05).

DISCUSSION

During the wet season, less number of individuals was recorded. According to Santoul *et al*. (2004), during the wet season the turbidity and total suspended solid significantly increased and the proportion of fish population significantly decreased at Lake Ikwori. These factors decrease the availability of food (fish) for greater cormorant during the wet season. Apparently, foraging behaviour is adapted to maximize energy gain per unit effort (Smith and Smith, 2003). For example, predators tend to forage in areas where their prey is abundant. When the density of prey population decreases to the level of scarcity, they switch to the nearby area with more abundant prey, ignoring areas with low number of prey (MacArthur and Pianka, 1966). Near to the study area (Lake Hora), there is a wetland called Cheleleka which serves as a feeding site for greater cormorants during the wet season. Greater cormorants switch between these two areas depending on the abundance of fish population.

In the current study, it has been observed that there is a significant positive relationship between surface pause duration and dive duration. This possibly suggests that the surface pause between successive dives represents a period of recovery from the physiological stress of diving. A positive relation between dive duration and subsequent recovery time was observed in other studies of cormorant species (Casaux, 2004).

It was found that the dive time of white-breasted cormorants significantly increased more at site 2 than site 1 during both the wet and dry seasons. Inter-seasonal dive duration also significantly increased during the wet season at both sites. This might be due to variation in water depth between sites, variation in fish abundance and seasonal variation in turbidity. Turbidity affects the prey locating ability of white-breasted cormorants. Pause duration is significantly related to the time the bird spent under water for searching, locating and capturing prey. Therefore, the factors that contributed for the variation of dive duration also contributed for pause duration.

Feeding site selection is important for the foraging success of cormorants, which catch fish on both vegetation-covered and naked sea beds, mostly in shallow water or at the shore side lakes and sea (Debout *et al*., 1995; Blackwell and Krohn, 1997). In the current study, birds were generally feeding near to the shore in the range between 10 and 30 m. This area has shallow depth compared to the centre of the lake. Site 1 is characterized by high human and livestock disturbances. During the study, it has been observed that people were gathering for ritual practices. They also brought their livestock in search of drinking water, salt licks and washing purposes. Site 2 (near to Mekoninoch Kibeb) is relatively with low disturbance. Such variation between sites might contribute for the variation in foraging bands. Birds forage at relatively further distance from human disturbance.

In the present study area, it was observed that white-breasted cormorants perched on trees, submerged rocks and raised grounds at the shore side. They preferred short height perching between 1 m and 3.5 m. One reason for such behaviour could be the possession of high wing loading and constant flapping during flight resulting in considerable energy costs (Owre, 1967).

The population size of the species in the study area varied between seasons. During the dry season, more number of birds of the species forage in the area. This is due to the local migration of individuals from the neighbouring seasonal swampy areas such as Lake Cheleleka and the less turbidity of

Lake Hora compared to the wet season. White-breasted cormorants depend on vision for searching and capturing prey in water. White-breasted cormorants forage in the shoreline of the lake where benthic fishes occur at the shallow depth. The foraging band is affected by the depth of water and the human disturbance in the study area. They forage more closely to the shoreline where there are fewer disturbances than the site where there are more disturbances. White-breasted cormorants can significantly change dive duration depending on the depth of water, turbidity of water and food availability. Dive duration is significantly associated with pause duration. They perch on trees, submerged rocks and raised ground above the water level whose height is not greater than 4 m. In the study area, wildlife resources including birds are affected by uncontrolled fishing, cultural gatherings and practices. These practices decrease the water carrying capacity and increase the biological oxygen demand (BOD) of the lake. Uncontrolled fishing apparently depletes the availability of fish in the lake, hence influences the abundance of food for fish-eating birds such as the white-breasted cormorant. For sustained conservation of the lake, such activities should be controlled by concerned and responsible governmental and non-governmental bodies.

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