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Population size and breeding ecology of Yellow-billed Duck (*Anas undulata*, Dubois 1839) in Chelekleka wetland, Ethiopia

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ABSTRACT: Yellow-billed Duck (*Anas undulata*) is a monomorphic African endemic dabbling duck protected by the Conservation of African-Eurasian Migratory Water birds Agreement. This study was conducted to investigate the population size and breeding ecology of Yellow-billed Duck in Chelekleka wetland, Ethiopia from November 2020 to October 2021. Census was conducted during early morning from 6:30 - 10:00 hrs and late afternoon from 15:30 - 18:00 hrs twice per week when the birds are active. Direct observations as well as nest and egg morphometry measurements were conducted to collect data on breeding ecology of Yellow-billed Ducks. During the study period, eight active nests were identified and followed. Data were analysed using R version 4.2 software. A maximum of 315 individuals of Yellow-billed Ducks were counted, with a significantly high population size during dry season compared to wet season ($Z = -10.85$, $df = 63$, $p < 0.001$). The female Yellow-billed Duck built a nest made up of herbs, defoliated leaves, dried grasses and thin twigs. The nest is circular shaped with a 26 - 32 cm in diameter and 7 - 11 cm in height. They laid eggs that are light brownish. Clutch size ranged from 5 - 8 eggs. The mean egg length, breadth and weight were 45.38 ± 1.65 mm, 39.17 ± 0.58 mm, and 45.4 ± 1.7 gm, respectively ($n = 21$). The average incubation period per nest was 19 ± 0.82 days ($n = 4$) with a high hatching success (98.1 %; $n = 53$). Supporting a considerable number of Yellow-billed Ducks, Chelekleka wetland is ecologically important for breeding and other related ecological requirements of the species. However, anthropogenic factors such as; burning of nesting bushes, wetland degradation, and agricultural expansions are highly threatened their survival. Therefore, sustainable conservation intervention is needed to minimize the threats on the species and its habitat.

Keywords/Phrases: Abundance, egg morphometry, nest, population size, wetland

INTRODUCTION

Yellow-billed Duck (*Anas undulata*) is an African endemic mallard-like Duck (Johnsgard, 2010) which is one of the 27 species of Anatidae occurring in Ethiopia (Lepage, 2022). It is a monomorphic dabbling duck (Young, 1999; Owen *et al.*, 2006) having a length of 52-58 cm and weight of 700-1150 g with displays grey-black feet and legs (Stacey *et al.*, 2019). The species has two sub species namely; the Abyssinian Yellow-billed Duck (*Anas undulata ruppelli*) which is resident in the upper Blue Nile and the Ethiopian lakes (endemic to Ethiopia) and the South African Yellow-billed Duck (*Anas undulata undulata*) which is resident in Angola, Zaire, Uganda, and Kenya south to the Cape (Johnsgard, 2010).

The population of Yellow-billed Ducks are characterized by nomadic nature (Dean and Skead, 1989). Globally, the estimated

subpopulations of Yellow-billed Duck were 20,000-60,000 birds in eastern Africa, more than 100,000 in southern Africa, and 20,000-50,000 northern East Africa (Wetlands International, 2006; Johnsgard, 2010). The population trend appears to be stable and is categorized as Least Concern in the IUCN Red List of Threatened Species (Bird Life International, 2016). However, due to the lead shot hunting, the species is protected by the Conservation of African-Eurasian Migratory Water birds Agreement (Owen *et al.*, 2006; Bird Life International, 2016).

The suitable habitats of Yellow-billed Duck are grassland, wetlands (inland), marine (neritic and coastal) environments (Bird Life International, 2016) and the species built its nest on the ground under dense, overhanging vegetation (del Hoyo, *et al.*, 1992). Factors such as hybridization, pollution, diseases and, invasive and problematic species are threats to the population of Yellow-billed Duck (Kear 2005; Bird Life International, 2016). In Chelekleka wetland, the species is

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threatened by anthropogenic factors such as habitat degradation through intensive irrigation and expansive of agricultural practices on the fringe of the wetland (personal observation).

In view of the serious situation of the rapid decrease of water bird diversity and abundance (Wang *et al.*, 2018) and poor data quality of Yellow-billed Ducks (Bird Life International, 2023) water bird conservation has received increasing attention worldwide (Wang *et al.*, 2018). In addition, improving knowledge about range and abundance on tropical birds is important for conservation strategies as most tropical regions remain poorly known (Tobias *et al.*, 2013). Furthermore, knowledge on the population size and breeding ecology of Yellow-billed Ducks in East Africa is lacking and hence quantitative studies on population size and aspects of breeding biology of the species is important to supplement adequate data to design proactive strategies for the conservation of the species. Therefore, the present study is aimed to estimate the population size and investigate the breeding ecology of Yellow-billed Duck in Chelekleka wetland, Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

Chelekleka wetland is situated at 8° 39' 0" - 8° 53' 0" latitude and 38° 49' 0" - 39° 3' 0" longitude and it is part of the Ethiopian Rift Valley ecosystem, located 51 km southeast of Addis Ababa (Fig. 1). The area is freshwater wetland and seasonally in undulated pan varying its size from year to year (Ethiopian Wildlife and Natural History Society (EWNHS), 1996), covering up to 24,000 ha (Bird Life International, 2021). It was originally supplied by runoff from Bishoftu town, and Teltele and Sofa highlands but now the construction of flood control dykes in the feeder streams and channelling runoff from the town to Lake Bishoftu reduced the size of the wetland (EWNHS, 1996). It is unprotected Important Bird Area (EWNHS, 1996), supporting hundreds of bird species in a highly degraded environment. Including endemics, the wetland harbors a variety of storks, herons, ducks, geese, waders, ibises, and birds of prey (EWNHS, 1996; 2010). The flora of the wetland is dominated by aquatic vegetation, such as *Typha* sp., grass sp. (sedges

and rushes), pondweeds, knotweeds and floating grasses. The study area is characterized by rugged topography with an altitude of 1800-1900 m a.s.l (Bird Life International, 2021). The annual rainfall and annual mean temperature ranges of the area are 5 - 232 mm and 8.5°C - 28.3°C, respectively (National Meteorological Service Agency, 2016).

Data collection

Population size

Census on population size of Yellow-billed Duck was conducted early morning from 6:30 - 10:00 hrs and late afternoon from 15:30 - 18:00 hrs twice per every week for 12 months during November 2020 - October 2021. A total of 96 days, 32 during the wet season and 64 during the dry season were carried out. Wet season data were collected from June to September 2021, while data for the dry season were collected from November 2020 to May 2021 and October 2021 according to the seasonal classification of the area by National Meteorological Service Agency (2016).

Census was conducted by two observers from vantage point. Prior to the commencement of counting, five vantage points were established that are relatively higher grounds, on the shore of the wetland and observers were trained on counting method of the Yellow-billed Ducks. The two observers counted the ducks on the same day at each vantage point separately. Both observers conducted the census starting from opposite direction; one started counting from the predetermined vantage point from the northern part of the wetland towards the southern end and the other observer vice versa. During counting, observers stopped at each of the established vantage points to carry out counting using binoculars (10 × 42) and naked eyes. Mean count of each vantage point was calculated as the average values recorded by both observers for the specific vantage points. The total number of the species per counting days was obtained as the sum of the mean values obtained from each vantage point on a particular counting day. During counting, birds that flew over the site quickly (usually taking less than 10 s) were not recorded. Additionally, census was not conducted during heavy rains and cloudy days to minimize under estimation of the bird species.

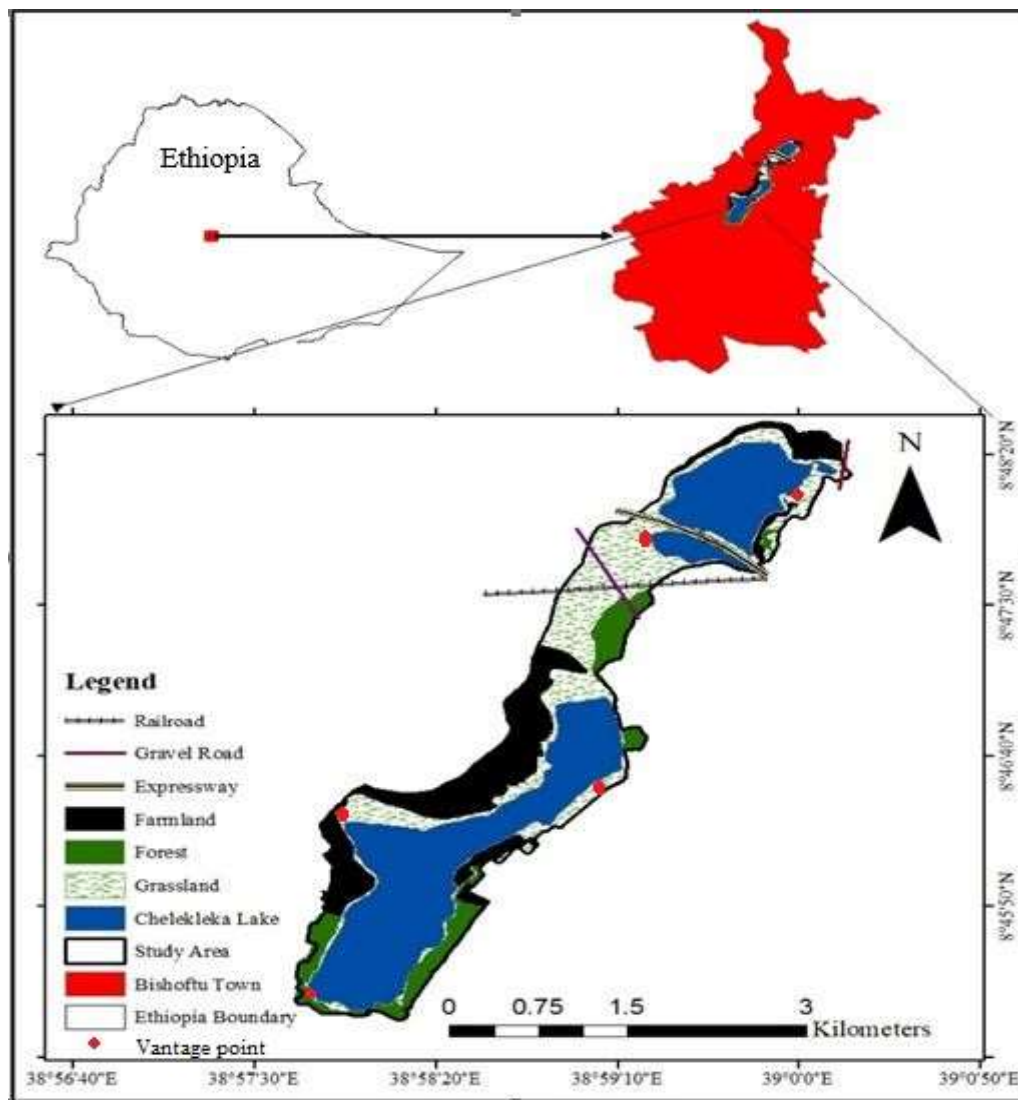


Figure 1. Map of the Chelekleka wetland, Ethiopia.

Breeding ecology

During population census any breeding activity was noted and followed. Data on breeding ecology of Yellow-billed Ducks were collected using direct nest searching and were followed from June to September 2021. The observations were assisted by Nikon binoculars (10 x 42) and / or naked eye. Intensive nest searching in the study area was carried along the margin of the wetland twice per week as per Austin *et al.* (1998). The identified nests were visited every other day to determine the clutch size and hatching success (Austin *et al.*, 1998). During nest observations, nest site selection, nest construction, distribution of nests, nesting material, courtship activities, pair formation, clutch size, incubation period, hatching success and parental care were recorded following Kumar (2012). Identification of nesting trees was carried out following Tadesse Mamo (2004).

Egg and nest morphometrics measurements of three of the eight active nests were conducted (Hayes *et al.*, 2000). Egg and nest morphometry were measured using digital calliper. Egg weight was measured using a digital balance (Austin *et al.*, 1998) (Fig. 2). Eggs were handled using a rubber gloves and placed in exact position and direction in the nest to minimize disturbance and egg rejection. Additionally, the covered eggs were carefully uncovered to count the clutch size and measure egg morphometry and once measurement was done, the eggs were covered back before the incubating Yellow-billed Duck returned.

Identification of threatening factors

Direct observation method was conducted throughout the study period, in parallel with other components of the study for identification of threats to Yellow-billed Ducks and its habitat.



Figure 2. Measuring egg morphometries of Yellow-billed Duck in Chelekleka wetland (Photo by Mebrat Teklemariam, 2021).

Data analysis

Data were analysed using R version 4.2 software (R Core Team, 2022). Population size of Yellow-billed Duck was assessed by taking the mean number of individuals from the the entire censuses of each month. Variation in the abundance of individuals between months was assessed using Chi-square test. General linear model (GLM, with Poisson link) was used to estimate the abundance (response variable) of the Yellow-billed Ducks in relation to the study seasons. To balance the frequencies of data collection (32 days) for both seasons, half of the data collection days during dry season were selected using systematic random sampling. Simple descriptive statistics such as mean and standard deviation were used to explore nest

and egg morphometric parameters and distance of the nests from the wetland.

RESULTS

Population size

The mean population size of Yellow-billed Duck in Chelekleka wetland was 117.67 ± 86.5 . The highest number of individuals was counted during February where a maximum of 315 individuals were counted. The lowest number of individuals (47) was recorded in July while no individual of the species was recorded during the month of April (Fig. 3). There was a significant difference in the population size of the species among the study months ($\chi^2 = 619.2$, $df = 11$, $p < 0.001$) (Fig.3).

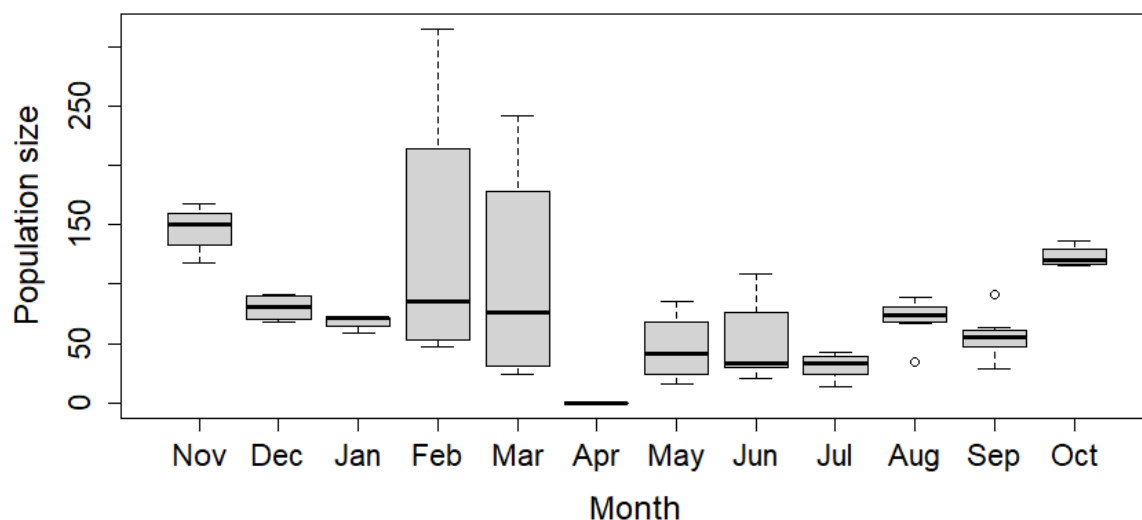


Figure 3. Population size of Yellow-billed Ducks at Chelekleka wetland. If the boxes of the box plots do not overlap, it suggests a significant difference between the medians of the different groups ($P < 0.05$). Conversely, if the boxes of the box plots overlap, it suggests that no be a significant difference between the groups ($P > 0.05$).

Seasonally, an average of 52 ± 25 individuals of Yellow-billed Ducks were recorded during wet season, whereas 88 ± 69 individuals during dry season. Population size of the species showed a

significant difference between wet and dry seasons ($Z = -10.85$, $df = 63$, $p < 0.001$) with the highest population record during the dry season (Table 1).

Table 1. Poisson model results obtained for the occurrence of Yellow-billed Ducks in dry and wet seasons.

Predictors	Population size		
	Incidence Rate Ratios	CI	p
(Intercept)	74.97	72.01 – 78.01	<0.001
Season [Wet]	0.71	0.67 – 0.76	<0.001
Observations	64		
R ² Nagelkerke	0.841		

Breeding ecology

Breeding pair formation

Pair formation was recorded at Chelekleka wetland starting from June that peaked in July. Group flights with an average of 24 ± 3.3 (Range: 18 - 30) individuals associated with different courtship displays and persistent quacking were part of the pairing process. These activities resulted in some males dropping out from the courtship groups. In addition, all individuals of adult Yellow-billed Ducks of the area were not joined the courtship flocks. Bill flick (flicks the bill rapidly to one side and showers water into the air), down-up (raises its head, stretches the

neck and downs the head), grunt-whistle (emits loud whistle followed by deep grunt), head-up-tail-up (draws its head and tail upwards), nod-swim (swimming in a circle around the female) and turn-back-of-the-head (shows the back of the head to the female) were the courtship displays used by male Yellow-billed Ducks.

Nest site selection and nest characteristics

During the breeding season which is June to September, a total of nine nests were located in the study area, of which one nest was inactive. Five active nests were located at lantana (*Lantana camara*) shrub land, two nests in umbrella thorn

acacia (*Vachellia tortilis*) woodland and one active nest on teff (*Eragrostis tef*) farm. The most preferred nesting site of the species was lantana shrub land (62.5 %). In addition, the ducks build

the nests close to the open water where the maximum distance nests located to the nearest open water were 7.8 m (Table 2).

Table 2. Nesting site selection of Yellow-billed Ducks at Cheleleka wetland.

Nestsite	Description	DNOW ^a (m)	No. of nests	Proportion (%)
Bush	Lantana (<i>Lantana camara</i>)	6.3 ± 3.14	5	62.5
	Umbrella thorn acacia (<i>Vachellia tortilis</i>)	1.5 ± 0.95	2	25
Farmland	Teff (<i>Eragrostis tef</i>) farm	7.8	1	12.5

^a Distance to the Nearest Open Water

The nests were made up of herbs, defoliated leaves, dried grasses and thin twigs. Sticks and leaves of *Lantana camara* were recorded as the main nesting material in nests located under this plant species. In the farmland habitat, the nest was made up of teff stems. The female Yellow-billed Ducks built a nest alone and only females incubated the eggs and guarded the nest. A very

important behavioural feature observed was the mother duck moult their feathers following laying of the last egg to cover their eggs when they leave the nest for foraging. In addition to their feather, defoliated leaves, thin twigs and dried grasses were also used to cover the eggs (Fig.4 A and B).



Figure 4. Nests of Yellow-billed Duck: Covered eggs (A, covered by dried leaves, feather and twigs and B, covered mainly by feathers) and Uncovered eggs (a and b) in Cheleleka wetland (Photo by Mebrat Teklemariam, A and a and Hailu Tilahun, B and b, 2021).

Nest and egg morphometry

Yellow-billed Ducks built a circular shaped nest on the ground with a diameter of 26-32 cm (Mean \pm SD = 29.67 \pm 3.22 cm; n = 3). The nests height ranges from 7 - 11 cm (Mean \pm SD = 9 \pm 2 cm; n = 3).

The eggs of Yellow-billed Duck are light brownish (Fig. 2 and 4). The average egg length was 45.38 \pm 1.65 (range: 41.2 - 47.9 mm) (n = 21) and breadth was 39.17 \pm 0.58 (38.26 - 40.05 mm) (n = 21). The eggs weighed from 41.2 to 47.9 g with a mean of 45.4 \pm 1.7 (n = 21) (Fig. 2)

Clutch size and hatching success

The mean clutch size was 6.63 eggs (range: 5 - 8, n = 8). The average incubation period per nest was 19 \pm 0.82 days (n = 4). From the total incubated eggs (N = 53), 98.1% were hatched. The hatchlings left the nest within less than 24

hours old and follow their mother. The mother duck dig out the nest facing the open water to facilitate the nest leaving activity. After departing the nest, ducklings hide under the dense floating grasses and were guarded by the mother Yellow-billed Duck.

Threats to breeding performance

Observation during the study period revealed that burning of nesting site plants, wetland degradation due to cultivation and irrigation on the fringe of the wetland, introduction of captive Mallards (*Nasplaty rhynchos*) on the wetland margin used by Yellow-billed Duck threatens the species and also other bird species supported by the wetland (Fig. 5). There is also a potential of diseases transmission due to the introduction of captive Mallards at the out skirts of the wetland that is home to different species of birds.



Figure 5. Threatening factors of Yellow-billed Ducks at Chelekleka wetland (a) burning of potential nesting bushes, (b) introduction of Mallards, (c) intensive irrigation and (d) farming encroachment on the fringe of Chelekleka wetland (Photo by Mebrat Teklemariam, a and b and Hailu Tilahun, c and d, 2021).

DISCUSSION

The Yellow-billed Ducks are resident birds that have occurred all year round in Chelekleka wetland as long as there is water or swampy areas in the wetland. In the current study, the wetland was dry in April so that the species

abandoned the wetland. Following the heavy rain in May, Yellow-billed Ducks returned to the wetland suggesting the nomadic nature of the species to exploit seasonal wetlands (Dean and Skead, 1989; Young, 1999). The highest number of Yellow-billed Ducks recorded during the dry months that peaked on February. This might be

due to the availability of food resources of the species during the drier months of the year in Chelekleka wetland. According to Lazli *et al.* (2014) favourable conditions found at a lake is accountable for the large numbers ducks at Lake Tonga, North-East Algeria.

Yellow-billed Duck forms small groups prior to starting breeding activity. Similar finding was also reported in South African sub-species of Yellow-billed Duck (Oettle, 2000). In the present study, breeding pairs were formed through complex courtship behaviours and both sexes have mate preferences although the courtship display was performed by the male. During courtship, the females avoided aggressive males. Similar behaviour has been recorded in dabbling ducks by Eadie and Savard (2014) and mallards by Wishart (1983). Remarkably, all types of elaborate courtship displays observed in the study area were consistent with the report of Young (1999) in Yellow-billed Duck.

Yellow-billed Ducks initiated nests immediately after the main rainy season in Chelekleka wetland. They breed during June to September. Similar findings were reported in South Africa where breeding of the species occurs shortly after the peak of the rainy season from June to September (Johnsgard, 2010) and from July-October (Little *et al.*, 1995). A study on reproductive status of Yellow-billed Duck based on their gonadal development revealed that this species breed throughout the year, though the exact breeding season varies annually due to variation in weather or rainfall, and other unidentified factors (Oettle, 2000). Regardless of the time of the year, the species is physiologically adapted to breed when water conditions are suitable (Johnsgard, 2010).

The breeding behaviour of Yellow-billed Ducks revealed that, females select nest-sites with better canopy cover and in a place where there is high proportions of sedge and flowering shrubs and under bushes to minimize predation risk. The nests were located close to water difficult to locate as they are secluded. Nesting sites of Yellow-billed Ducks are an area with thick, grassy vegetation occurs near water as was reported by Johnsgard (2010). Even though, nest site requirements and means of avoiding predation vary between most duck species, their nests are difficult to detect by predators (Väänänen, 2001) similar to the present finding. Ground nests constructed from dead/defoliated parts of the vegetation to cover incubating eggs was also reported by Brihadeesh and Rajaram (2015) on Indian Spot-billed Duck (*Anas*

poecilorhyncha) that builds nest in marshy margins of freshwater bodies in a pad of grass and weeds.

The clutch size of Yellow-billed Ducks was in line with the report of Johnsgard (2010), in which clutch sizes of 4-10 eggs were reported in the same species. The incubation length of the species in the study area is less than its South African race as described by Johnsgard (2010) where its incubation period was recorded as 27 days. The variation might be due to the difference in race and climate. Caldwell (1975) mentioned high temperatures tended to shorten incubation period while rain and cold tended to lengthen it. Like other dabbling ducks (Eadie and Savard, 2014) female Yellow-billed Ducks incubated the eggs and raised the young.

In the present study the hatching success was high since almost all incubated eggs were hatched. The highest hatching success might be due to the potential of the wetland to achieve the ecological requirements of the species and the occurrence of minimal nest predation risk. In dabbling ducks, the cryptic coloration of incubating females is important for making females and nests more difficult to detect by predators to avoid nest and incubating birds' predation (Väänänen, 2001). One egg was unhatched and this might be due to infertility since the egg remained in the nest, undamaged, throughout incubation period. Arnold (1993) also mentioned that an average of 10% of bird eggs fail to hatch owing to infertility and other forms of embryo mortality related to the length of time between egg laying and incubation.

In Chelekleka wetland, burning of bushes that are important for nesting and agricultural expansion poses a serious threat on the breeding activity of Yellow-billed Duck. Tarboton *et al.* (1987) noted in ground nesting Yellow-billed Duck that loss of suitable nesting bushes resulted in the loss of breeding colony of this species. Additionally, the intensive irrigation on its fringe coupled with high evaporation resulted in complete dryness of the wetland during April that caused Yellow-billed Ducks to abandon the area. Loss of wetland habitats on which Yellow-billed Ducks depend for foraging threatens the birds (Monadjem *et al.*, 2003, Anderson, 2005). Further, the introduction of mallards that are vaccinated, but might be a reservoirs of contagious and/or infectious pathogens can result in the transmission of diseases while the ducks get into close contact with mallards during foraging posing a serious threat to the species.

CONCLUSION

Chelekleka wetland supports a considerable population of Yellow-billed Ducks for their foraging and breeding activities. The population size of this species varies with seasons and months depending on the availability of foraging and/or breeding ground. Passionate group flights accompanying with different courtship displays as well as tireless quacking indicate the commencement of breeding season in Yellow-billed Ducks. Even though, the species build nests in different land use types using different nest construction materials, bushes with high canopy cover especially, *Lantana camara* were the most preferred nest sites. In addition, defoliated leaves and dried grasses are the most preferred nest construction materials. Yellow-billed Ducks camouflage with the environment to avoid nest predation. Breeding takes place during wet season with high breeding success. Unfortunately, the wetland is highly degraded mainly due to anthropogenic factors posing a serious a threat on the foraging and breeding ecology of the yellow-billed Duck and other bird species. Hence, immediate conservation intervention to minimize the threats is required for the sustainability of the wetland and its inhabitants.

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