https://doi.org/10.48047/AFJBS.7.4.2025.1398-1422

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Breeding biology and distribution of Ferruginous Duck *Aythya nyroca* (Aves, Anatidae) in a site Ramsar (North-east Algeria)

Fatima Mecif , Amel Lazli , Sana Naili , Sara Benmetir , Roumaissa Soltani , Abdennour Boucheker

[1] *Laboratory of Environmental Sciences and Agro-ecology. Department of Biology. Chadli Bendjedid University - BP: 73. 36000 El Tarf- Algeria*

[2] *Laboratory of Biodiversity and Ecosystems Pollution. Department of Biology. Chadli Bendjedid University - BP: 73. 36000 El Tarf - Algeria.*

[3] *Laboratory of Wetlands Conservation (L.C.Z.H).University May 8, 1945 Guelma, BP 401, 24000 Guelma, Algeria*

**** Corresponding Author*:** Email- Adress : fati_mecif36@yahoo.com **Phone number:** +213 662660234

Volume 7, Issue 4,Apr 2025

Received: 15 Feb 2025

Accepted: 05 Mar 2025

Published: 05 Apr 2025

doi:10.48047/AFJBS.7.4.2025.1398-1422

Abstract

Between September 2015 and August 2017, a study was carried out at Lake Tonga (North-East Algeria), on the breeding biology and habitat selection of Ferruginous Duck *Aythya nyroca* Güldenstädt 1770 (Aves, Anatidae), a species listed on the IUCN Red List as "near-threatened".

This work was based on regular monitoring of the species' population numbers and the study of its breeding biology (nest and egg characteristics, laying dates and periods, clutch size, hatchlings and breeding success). In addition, we identified the species' nesting sites, in particular through the birds' distribution across the water body.

We recorded monthly and seasonal fluctuations in species numbers. The largest ones were counted during August 2016 and September 2017, with respective peaks of 1324 and 1483 individuals. Nests were found mainly in Typhas, Bulrushes, Phragmites and other floating islands composed of various plant associations. The highest number of eggs was recorded in June for both survey years. Clutch size was 9.36 (N= 112 clutches). Hatching success rate was 81.9% in 2016 and 69.6% in 2017. Factors that may have influenced nesting success were desertion, predation, egg loss and intra- and interspecific parasitism.

Key words: Ferruginous Duck, Lake Tonga, abundance, nest, clutch size, hatching, breeding success, selection.

INTRODUCTION

Algerian wetlands play an important role in the migration, wintering and breeding of a multitude of bird species, including Anatidae, the most abundant group of waterbirds in North African wetlands (Heim De Balsac and Mayaud, 1962; Van Dijk and Ledant, 1983; Isenmann and Moali, 2000; Thévenot et al., 2003 and Isenmann et al., 2005), particularly in Algeria (Lazli et al., 2018; Bediaf et al., 2020; Loucif et al., 2021and Gherib et al., 2021).

In the east of the country, Lake Tonga is a good example of a representative, rare and unique "natural wetland" in the Mediterranean region. It is located in a wetland complex that ranks third after the Ebro Delta in Spain and the Camargue in France (Zitouni et al., 2014). This Ramsar site is home to a multitude of waterbird species, including one of the most emblematic, the Ferruginous Duck *Aythya nyroca* Güldenstädt 1770, which is listed by the IUCN as a near-threatened species.

Over recent decades, its global population has declined markedly and its distribution changed (Robinson and Hughes, 2006 and BirdLife International, 2019). The species winters in the Mediterranean basin and in tropical Africa in the West, also on the large wetlands of Western and Central Asia in the East (Robinson and Hughes, 2003). Lake Tonga hosts a sedentary breeding population that has been estimated at: 1024 individuals in 1991 (Boumezbeur, 1993), 2326 in 2008 (Lazli, 2011) and 1947 in June 2014 (Gherib et al., 2021).

Various studies have been carried out in recent years on the Ferruginous Duck in the eastern Algeria wetlands, particularly the El Kala wetland complex, that of Guerbès-Sanhadja and wetlands of the “Hauts plateaux” (Lazli, 2011; Aissaoui, 2012; Houmani, 2012; Draidi, 2014; Merzoug et al., 2014; Abdellioui, 2017; Djelailia, 2016; Gherib and Lazli, 2017; Ayaichia, 2018; Gherib, 2018 and Rizi et al., 2019). These studies have contributed more or less to the knowledge of the species, but very few have been devoted to its nesting sites selection.

This research aims to monitoring the Ferruginous Duck population' demographic trends over two annual cycles and study its breeding biology. It also attempts to characterise its nesting sites and identify the factors that may affect its reproductive performance.

MATERIALS AND METHODS

Study site

The study was conducted in Lake Tonga, located in El-Tarf region, in the extreme north-east of the country (Fig. 1). It is a protected area within the El-Kala National Park (PNEK) and has been listed since 1982 as a Ramsar site of international importance (Lazli, 2011; Menasria and Lazli, 2017; Gherib, 2018; Mecif et al., 2020 and Gherib et al., 2021).

It is a freshwater marsh covering an area of 2600 ha (Fig. 2), connected to the sea by the Messida artificial channel. It plays an important role in the annual life cycle of numerous waterbird species.

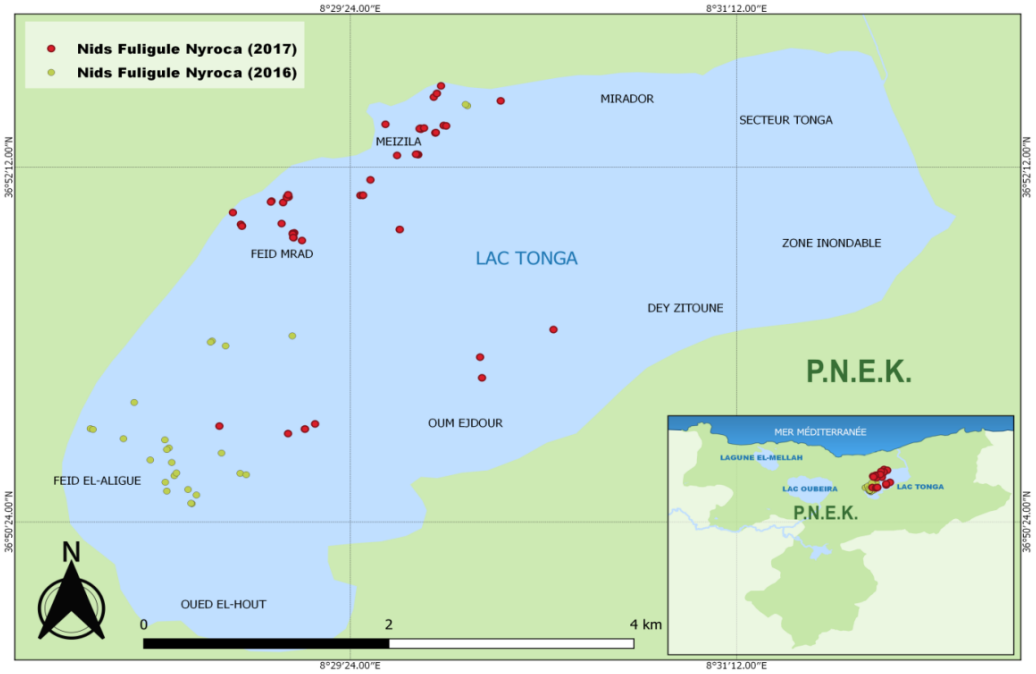

Figure 1. Location of Lake Tonga and nests found during 2016 and 2017.

Around 80% of Lake Tonga is covered by emergent vegetation composed of helophytes dominated by *Phragmites australis*, *Typha angustifolia* and a mixture of *Scirpus lacustris*, *Sparganium erectum* and *Iris pseudacorus* (Saïfouni et al., 2020), with large areas of open water largely occupied by the White Water Lily *Nymphaea alba*, particularly during the nesting period (Lazli et al., 2011a, 2012; Mecif et al., 2020). The submerged and floating vegetation of this site is dominated by the Shining Pondweed *Potamogeton lucens* and the Whorled leaf water milfoil *Myriophyllum verticillatum* (Fig. 3) (Rizi et al., 2019).

Figure 2. View of Lake Tonga during the wintering period taken from the observation stations of Meizila (Mecif F., 2016)

Figure 3. Vegetation islands in Lake Tonga during the breeding season (Mecif F., 2017)

Because of its habitat diversity and the richness of its trophic resources, Lake Tonga is home to a large number of nesting species such as the Common Coot *Fulica atra*, Great Crested Grebe *Podiceps cristatus*, Little Grebe *Tachybaptus ruficollis*, colonies of Squacco Heron *Ardeola ralloides*, Black-crowned Night-heron *Nycticorax nycticorax*, Purple Heron *Ardea*

purpurea, Glossy Ibis *Plegadis falcinellus*, Whiskered Tern *Chlidonias hybrida*, etc. (Mecif et al., 2020 and Naili et al., 2021).

In recent years, Lake Tonga has been confronted with a number of threats, including bank erosion, direct pumping of its water, especially during the summer period, pollution from wastewater discharges and agricultural fertilisers, which gradually cause its eutrophication, multiple disturbances (hunting, egg collection or recreational activities), clogging of the water body by vegetation and clogging of its channel, recreational activities), the clogging of the water by vegetation and the clogging of its channel, all of which threaten the survival of this particular ecosystem and the nesting of many species of waterbird (Lazli et al., 2011b; Gherib and Lazli, 2017 and Benmetir, 2021).

Methods

Bird counts

Monitoring of Ferruginous Duck numbers at Lake Tonga was conducted from September 2015 to the end of August 2017, at a frequency of three visits per month, thus covering almost the wintering and breeding periods. Surveys were carried out from nine (09) observation points or stations (Flood zone, Sector of Tonga, Mirador, Meizila, Feid Mrad, Feid El Aligue, Oum Ejdour, Oued El Hout and Dey Zitoune, used in previous studies (Fig. 4) (Boumezbeur, 1993; Lazli et al., 2011a, 2011b; Lazli et al., 2012 and Gherib et al., 2021).

To scan the entire water body, we used a Konus-Spot telescope (20 x 60) and a pair of binoculars (10 x 50). In order to avoid any disturbance to birds, the counts were made from a rowing boat and sometimes from natural promontories or from the two watchtowers located west and south of the lake.

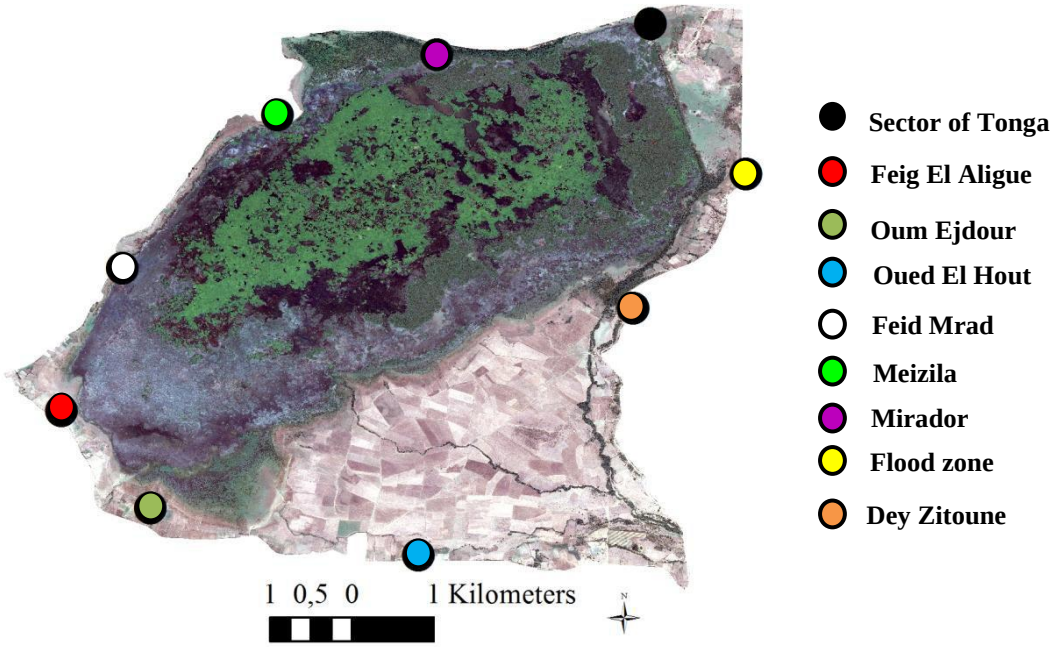

Figure 4. Location of observation stations (black spots) around Lake Tonga

Reproductive biology

The study of the species' breeding biology was conducted between March and the end of August 2016 and 2017. During which we carried out:

Nest search and location

This consists of sweeping the emergent plants and floating vegetation islands over the entire surface of the study area to identify habitats likely to support nests. Once located, the latter were first numbered; their geographical position recorded using a GPS and marked to find them easily. Nests were then inspected two to three times a week to detect the first egg-laying, from the beginning of the breeding season (March) until the hatching of the last eggs (August).

Nest and egg characteristics

We measured the internal and external diameters and the height of nests. An important factor was also taken into account, and that was the vegetation, in particular the building materials (determination of the different plant species used and the proportions of each).

Eggs were marked and weighed using a "Pesola" spring balance (precision 0.01 g). Their length and width were measured with a precision calliper of 0.1 mm. Their volume (V, in mm3) was determined using HOYT's formula ($V = 0.000509 * \text{length} * \text{width}^2$) (Hoyt, 1979).

Breeding parameters

There were the date and period of laying, laying size (number of eggs that a female can lay in a nest), hatching success (number of eggs hatched out of the total number of eggs laid) and breeding success (number of nests hatched out of the total number of nests monitored or occupied). Finally, the cases of intraspecific parasitism (determined by the rule of laying one egg per day, the presence of newly added eggs after the laying has been completed (Cramp & Simmons, 1977), the absence of synchronisation during hatching (Lyon, 1993; McRae, 1997 and Jamieson et al., 2000) and the cases of interspecific parasitism (determined by the presence of one or more eggs of another species in the nest).

Distribution of Ferruginous Duck numbers and nests

During our field investigations, we monitored the distribution of the Ferruginous Duck population and its nests across the water body, by identifying the locations of the largest numbers of the species and the vegetation supporting nests.

Data analysis

Data analysis was performed with R-version 3.6.1 (05-07-2019). The results are presented as means ± standard deviation and $P<0.05$ was used as the significance threshold. Correlations between nest measurements and water depth at their location were tested using the correlation coefficient.

The Student's t test was used to determine whether there was a difference between numbers counted in the two years considered and also between nest dimensions, between egg-laying sizes and to check whether egg dimensions were different during the different study years.

RESULTS

Ferruginous Duck counts

Monitoring of the Ferruginous Duck population at Lake Tonga showed monthly number variations (Fig. 5). Two peaks were recorded: a first in August 2016 (1324 individuals) and a second in September 2017 (1483 individuals).

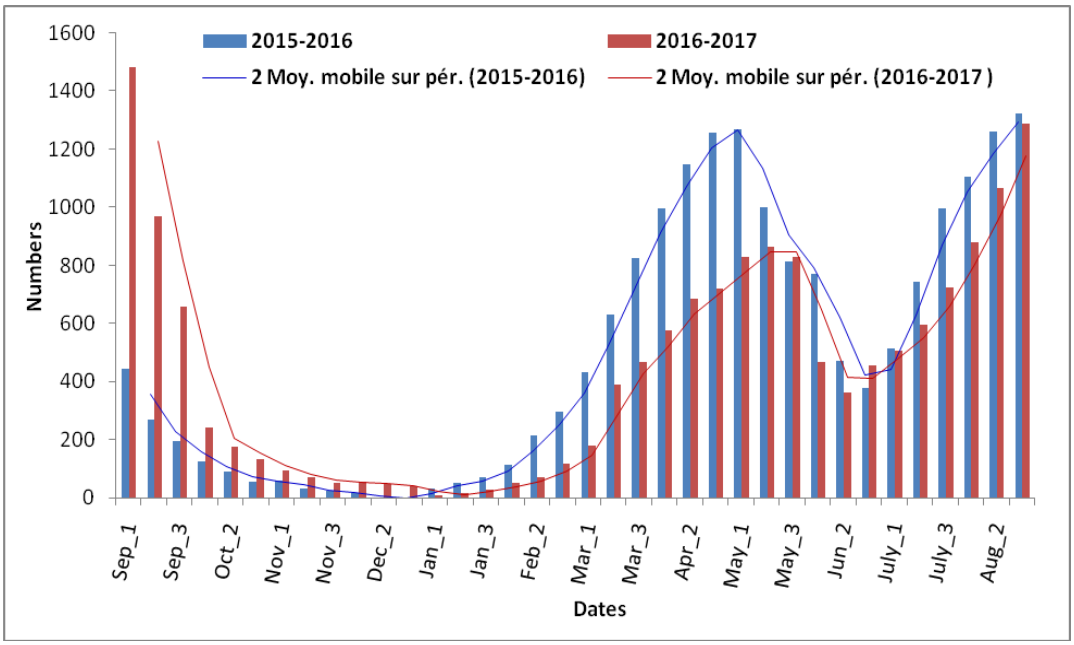

Figure 5. *Changes in numbers of Ferruginous Duck at Lake Tonga during the study period.*

As showed in figure 6, there was no significant difference between numbers counted during the two study years (t=0.5; p=0.616).

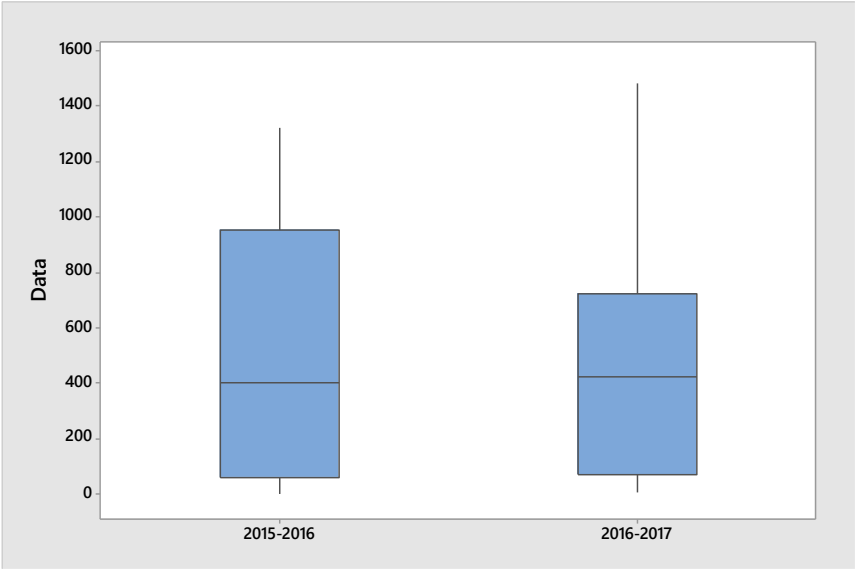

Figure 6. Boxplot of 2021-2022 and 2022-2023

Study of Ferruginous Duck breeding biology at Lake Tonga

Nest building materials

After an active search for nests during the two study seasons, we found 142 nests, 35 in 2016 and 107 in 2017. They were well hidden in the very dense and high vegetation. Almost all of

them were located inside the lake, some on the banks or along the edges inside Alder trunks, particularly in the Alder grove of the Arboretum of Lake Tonga.

It should be noted that in 2016, all of the nests were scattered throughout the lake's vegetation, however in 2017, most of them i.e. 67 (≈ 63%), were dispersed on 16 floating islets with varied plant structures which were composed of different plant associations: Club Rush *Scirpus lacustris*, Purple Loosestrife *Lythrum salicaria*, Common Reed *Phragmites australis*, Lesser Bulrush *Typha angustifolia*, Willow *Salix pedicellata*, Gypsywort *Lycopus europaeus*, Yellow Iris *Iris pseudacorus*...

Nest-building materials consisted almost entirely of plant stems and dry leaves taken from the surrounding area, such as plant debris of Typhas, Phragmites, Bulrushes, sedges and other aquatic plants, lined with down.

These nests were discovered from April in 2016 and from May in 2017. The last ones were found in July in 2016 and in August in 2017.

Characteristics of nests and eggs

The nests' external diameter varied between 18 and 31 cm in 2016 and between 17 and 35 cm in 2017. Internal ones ranged between 8 and 22 cm in 2016 and between 09 and 20 cm in 2017 (Tab. 1). Their average height was 31.17 cm in 2016 and 33.79 cm in 2017 and their depth varied between 6 and 20 cm between the two years (Tab. 1).

Data analysis showed no significant differences in nest dimensions (external and internal diameters, height) between 2016 and 2017 ($P<0.05$), except for nest depth between the two years (Tab. 1).

Table 1. Characteristics of Ferruginous Duck nests and eggs in Lake Tonga for 2016 and 2017

	Years							
	2016				2017			***Student t test***
Nest Parameters	**N**	**Min.**	**Mean ± SD**	**Max.**	**N**	**Min.**	**Mean ± SD**	**Max.**	
Nest external diameter (cm)	35	18	24,4 ± 3,35	31	107	17	25,04 ±3,99	35	t=-0,97 ; df=68 ; p=0,335
Nest internal diameter (cm)		8	15,11 ± 2,68	22		09	15,73 ± 2,46	20	t=-1,20 ; df=54 ; p=0,234
Nest depth (cm)		8	12,63 ± 2,78	20		06	10,05± 2,00	19	t=5,09 ; df=46 ; p=0,000 ***
Nest volume (cm^3)		2543,4	6021,17±2331,51	15087,7		2041,78	5142,61±2173,57	10889,52	t = 1,97 ; df = 54 ; p= 0,054
Nest height (cm)		16	31,17 ± 9,48	53		09	33,79 ±23,59	16	t=-0,94 ; df=134 ; p=0,348
Water depth (cm)		90	114 ±18,0	160		80	115,09 ±19,96	160	t=-0,26 ; df=63 ; p=0,792
Distance to nearest nest (cm)		40	3032±3706	2000		50	1482 ±2085	1000	t = 2,29 ; df = 41 ;p= 0.027**
Height of vegetation around nest (cm)		65	200±73,00	400		60	217,57±89,86	600	t=-1,15 ;df=70 ; p=0,256
Egg Parameters	**N**	**Min.**	**Mean ± SD**	**Max.**	**N**	**Min.**	**Mean ± SD**	**Max.**	***Student t test***
Egg length (mm)	199	47,42	51,08±1,58	54,98	849	44,39	51,40±1,90	59,92	t = -2,59 ; df = 358 ; p = 0,01**
Egg width (mm)		35,49	37,57±0,85	40,29		33,85	37,49±1,12	44,56	t = 1,09 ; df = 379 ; p = 0,278
Egg weight (g)		31	39, 29±3,09	47		30	40,08±3,28	49	t = -3,23 ; df = 310 ; p= 0,001***
Egg volume (mm^3)		31,32	36,74±2,40	44,00		28,09	36,86±3,33	55,83	t = -0,60 ; df = 396 ; p = 0,549

* ***SD :*** *Standard Deviation*

Analysis of data obtained during the two breeding seasons show correlations between certain characteristics of nests ($p<0.05$) (Tab. 2, 3).

Table 2 : Results of correlations between nest characteristics for 2016 breeding season ($p<0.05$).

	N._ ext._D.	**N._int._ D.**	**Nest depth**	**Nest Height**
Nest internal diameter	r=0,565 P=0,000			
Nest depth	r=0,075 P=0,667	r=-0,354 P=0,037		
Nest height above water level	r=0,398 P=0,018	r=0,396 P=0,019	r=-0,187 P=0,281	
Nest Volume	r=0,749 P=0,000	r=0,137 P=0,431	r=0,682 P=0,000	r=0,166 P=0,341

***** ***N._ ext._D. :*** *Nest external diameter;* ***N._int._ D. :*** *Nest internal diameter*

Table 3 : Results of correlations between nest characteristics for 2017 breeding season ($p<0.05$).

	N._ ext._D.	**N._int._ D.**	**Nest depth**	**Nest Height**
Nest internal diameter	r=0,543 P=0,000			
Nest depth	r= 0,240 P=0,013	r=0,411 P=0,000		
Nest height above water level	r= 0,188 P=0,053	r= -0,238 P=0,014	r= 0,043 P=0,662	
Nest Volume	r= 0,878 P=0,000	r= 0,607 P=0,000	r= 0,650 P=0,000	r=0,166 P=0,341

***** ***N._ ext._D. :*** *Nest external diameter;* ***N._int._ D. :*** *Nest internal diameter*

Ferruginous Duck eggs are elliptical to sub-elliptical, short oval in shape, with a smooth, matt shell and a light beige colour. 1,052 eggs were found in Lake Tonga during the study period: 199 in 2016 and 853 in 2017 (Tab. 1). Their length varied between 47 and around 55 mm in 2016 and between 44 and nearly 60 mm in 2017. The average width was: 37.57 mm in 2016 and 37.49 mm in 2017 (Tab. 1). Egg volume ranged from 28 to around 66 mm3 over the two breeding seasons.

Breeding parameters

Egg-laying

The first egg-laying was recorded on 19 April in 2016 (n=26 nests) and on 20 May in 2017 (n=86 nests). The last ones were recorded at the beginning of July in 2016 and during the third week of July in 2017 (Tab. 4).

Table 4. Estimated laying dates, laying period, incubation and hatching dates for Ferruginous Duck at Lake Tonga

Years / Parameters	2016	2017
1st Egg-laying date	19th April	20th May
Laying date of latest brood	July 1st	18th July
Laying period	09 weeks	11 weeks
Incubation onset	29th April	June 1st
Incubation end	11th July	23th July
Start of hatching	24th May	26th June
End of hatching	31th July	15th August

The highest egg laying numbers were recorded in June for the two study years: 17 and 52 eggs respectively.

Clutch size

Clutch size varied between 5 and 12 eggs in 2016 and between 2 and 22 eggs in 2017 (Fig. 7). The average clutch size ranged from 8 (N=26) to 10 eggs (N=86) (Tab. 5).

Data analysis shows significant differences between 2016 and 2017 clutch sizes ($t = -3.59$; ddl = 100; $p = 0.001$).

Table 5. Clutch size of Ferruginous Duck at Lake Tonga during the two breeding seasons studied

Years	Brood number	Clutch size (Mean±SD) (Extreme values)	Egg number
2016	26	7,65 ± 1,87(5 - 12)	199
2017	86	9,87 ± 4,59(2 - 22)	849

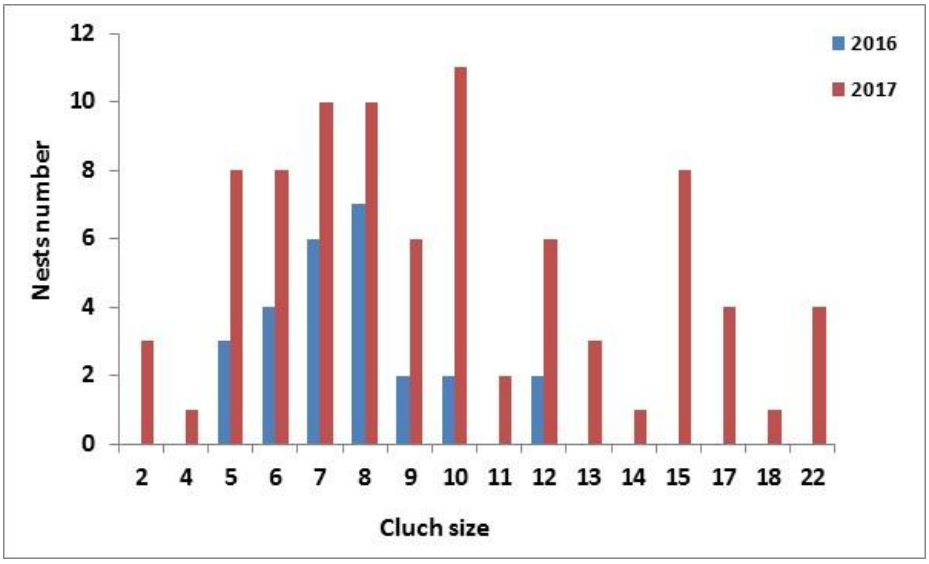

Figure 7. Variation in clutch size of Ferruginous Duck in Lake Tonga during the study period

Hatchlings

First hatchlings were discovered during the fourth week of May in 2016 (N=23 nests) and during the fourth week of June in 2017 (N=69). Last ones were observed towards the end of July in 2016 and during the second week of August in 2017. The maximum number of hatchlings was recorded in July for both study years.

Hatching success was 81.9% in 2016 and 69.6% in 2017.

During our study, we recorded a number of egg losses: 18% in 2016 and 30.4% in 2017. These losses were due to various causes: unhatched eggs, eggs that had been predated, broken eggs... (Fig. 8).

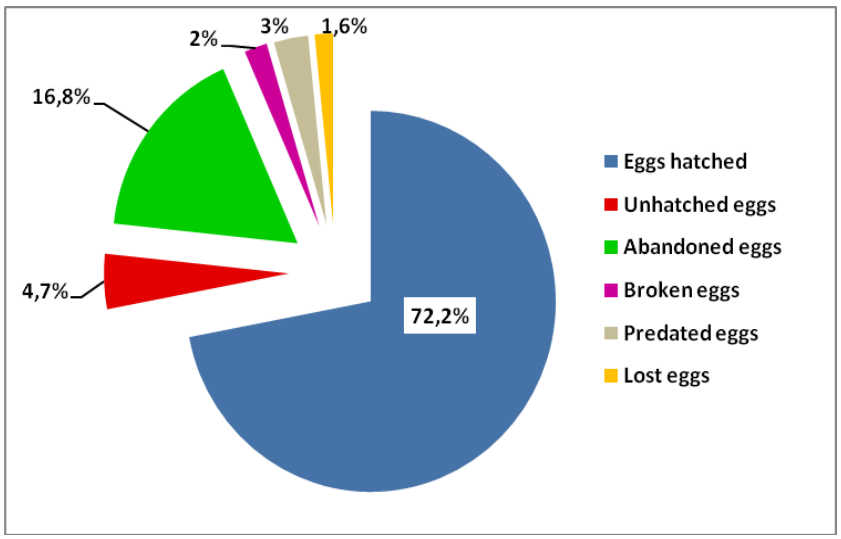

Figure 8. Percentage of Ferruginous Duck egg losses at Lake Tonga

Breeding success

Of all the nests monitored, 23 hatched at least one chick in 2016, i.e. around 66%, and 69 in 2017, i.e. 64.5%.

Of the 35 nests discovered in 2016, there was one case of abandonment, one case of flooding and one case of predation. In 2017, of the 107 nests found, 12 were abandoned, 03 suffered predation and 02 did not hatch. In addition, we missed the reproduction of 09 nests in 2016 and 21 in 2017. These nests were found during our first visits with hatching traces inside.

During our field surveys, between May and July, we recorded a few cases of nest predation. Indeed, we observed Marsh Harriers *Circus aeruginosus* flying over vegetation islands, rodents *Rattus rattus* and Viperine snakes *Natrix maura* near nests (Fig.9), some of which contained broken eggs, dead chicks and once female feathers scattered.

Figure 9. *Natrix maura* near Ferruginous Duck nests

Cases of brood parasitism were noted in 2017 during our field monitoring: 02 cases of interspecific parasitism, where each nest contained 01Purple Swamphen egg, and 09 cases of intraspecific parasitism, with clutch sizes ranging from 17 to 22 eggs.

Distribution of Ferruginous Duck numbers at Lake Tonga

Surveys of the species in Lake Tonga revealed its distribution throughout the water body. Some stations have been home to large numbers depending on the season.

The north-western stations of Meizila and Mirador were the most frequented by birds during the annual cycle, but especially between September and December during the first year of the

study (wintering season) (Fig. 10). During the breeding season, numbers appear to be almost evenly distributed between the north-western and southern stations (Feid El Aligue and Feid Mrad) (Fig. 10).

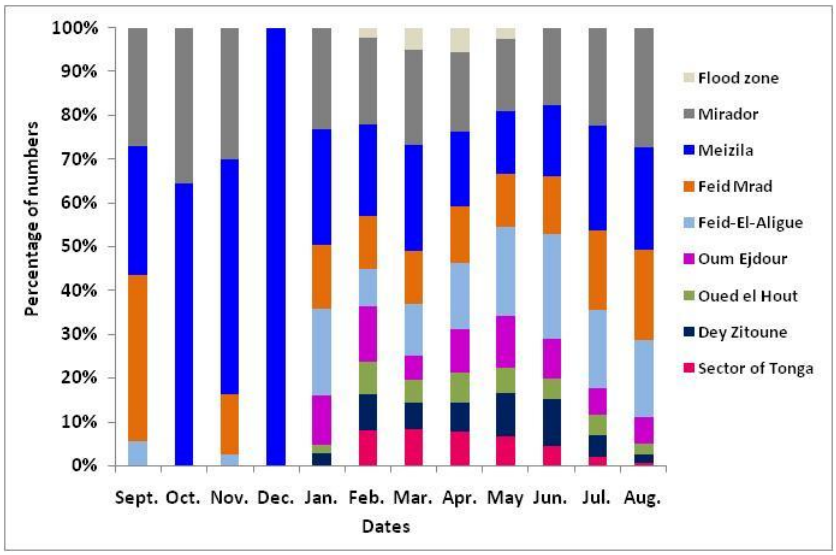

Figure 10. Ferruginous Duck numbers expressed as percentages and counted at the different sites during 2015-2016.

In the second year, the north-western Tonga stations, Meizila and Mirador, continued to host the highest numbers between September and January (wintering season) (Fig. 11). During the nesting season, these two stations shared with those on the southeast and south shores a more or less equal number of individuals of Ferruginous Duck (Fig. 11).

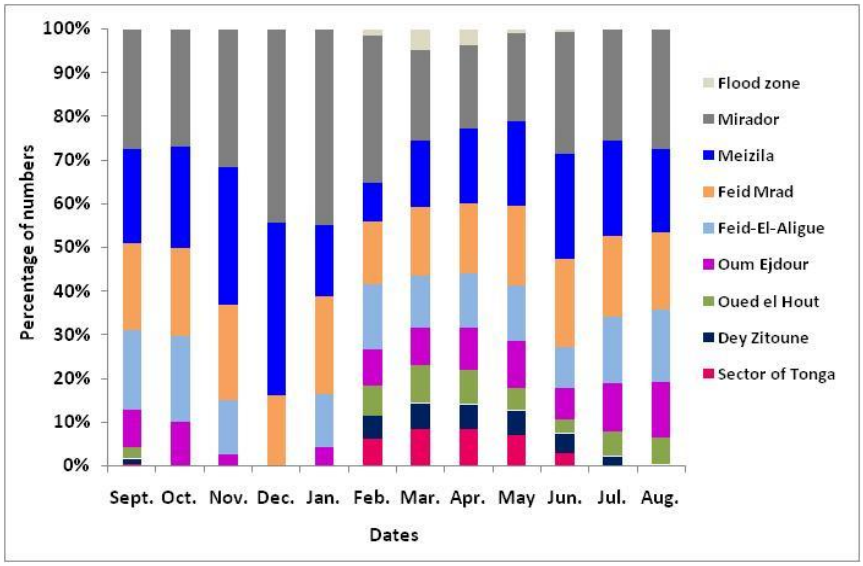

Figure 11. Ferruginous Duck numbers expressed as percentages and counted at the different sites during 2016-2017.

Distribution and location of nests

After an active search for nests during the two study seasons, we found 142 nests, 35 in 2016 and 107 in 2017. They were well hidden in the very dense and high vegetation. Almost all of them were located inside the lake, some on the banks or along the edges inside Alder trunks.
It should be noted that in 2016, all of the nests were scattered throughout the lake's vegetation, however in 2017, most of them i.e. 67 (≈ 63%), were dispersed on 16 floating islets with varied plant structures which were composed *Scirpus lacustris*, *Phragmites australis*, *Typha angustifolia*, *Salix pedicellata*…

DISCUSSION

The Ferruginous Duck is a common bird in North Africa, particularly in Algeria, where it has been recorded in Numidia, especially in the El Kala wetland complex (Boumezbeur, 1993; Isenmann and Moali, 2000; Lazli et al., 2012; Lardjane-Hamiti et al, 2013; Fouzari et al., 2015; Merzoug, 2015; Gherib and Lazli, 2017; Gherib, 2018; Lazli et al., 2018; Narsis et al., 2019 and Loucif et al., 2021) and Guerbès-Sanhadja complex (Metallaoui and Houhamdi, 2010; Atoussi, 2014; Merzoug, 2015 and Abdi et al., 2016).

At Lake Tonga, it is known as a sedentary breeder. The species is observed throughout the year, with numbers varying between wintering and nesting seasons (Boumezbeur, 1993; Aissaoui et al., 2009; Lazli, 2011; Lazli et al., 2012; Gherib, 2018; Rizi et al., 2019; Narsis et al., 2019; Gherib et al., 2021 and Loucif et al., 2021).

Monitoring of Ferruginous Duck population trends at Lake Tonga revealed a certain dynamic over the study period. Indeed, during the two wintering seasons, we recorded low numbers between late October and late January reflecting the presence of only sedentary birds and an increase from the second week of February, indicating the gradual arrival of breeding birds and the start of the breeding season. This result is consistent with Boumezbeur (1993) and Lazli (2011) studies.

Winter numbers seem low compared with those reported at the same site (Boumezbeur 1993; Aissaoui et al., 2009; Lazli et al., 2012 and Narsis et al., 2019). These numbers would be attributed to the presence of Nyrocas and other Anatidae in other wetlands close to Lake Tonga that have more water, such as Lake Oubeira and Lake “des oiseaux” (Houhamdi and Samraoui, 2008 and Lazli et al., 2018). It should also be noted that these two studied years

were experienced harsh climatic conditions, in particular a lack of rainfall, which was responsible of the lake shallow water depth, given that the species, by its ecology, is a diving duck.

Important numbers recorded in August 2016 and September 2017 suggest post-nuptial gatherings of adult and juvenile individuals as reported in Lazli (2011) and Lazli et al. (2012). Concerning nest building materials, those cited by various authors at Lake Tonga or elsewhere in other wetlands in Algeria generally appear to be similar to ours (Aissaoui et al., 2009; Lardjane-Hamite, 2013; Merzoug, 2015 and Narsis et al., 2019). The dimensions recorded during the study period seem close to those of Boumezbeur (1993) and Narsis et al. (2019) at the same site, but smaller than those reported by Djelailia et al. (2017) and Loucif et al. (2021) at Lake Tonga. At Garaet Hadj Tahar, Merzoug (2015) noted larger measurements than those collected during our investigations. These differences in nest size could be due to a higher water level or to the greater risk of predation during our study, which led these birds to build smaller nests to protect their eggs and later their chicks from any threat.

More than 1000 eggs were counted at Lake Tonga. Their dimensions (length, width, weight, volume) varied between the two seasons studied, but were very close to those reported at the same site by Boumezbeur (1993), Fouzari et al. (2015), Djelailia et al. (2017), Gherib (2018), Narsis et al. (2019) and Loucif et al. (2021); and slightly larger than the eggs found at Garaet Hadj Tahar by Merzoug (2015). A comparison of our data with those provided by other authors shows that our results are perfectly within norms (Etchecopar, 1964; Ali and Ripley, 1968 and Cramp and Simmons, 1977). The minor differences in dimensions between our results and those of Merzoug (2015) are due to the small size of his samples (n=4). Thus, due to the richness and diversity of habitats in Lake Tonga, Ferruginous Duck have been able to find the necessary conditions and resources for egg production and chick rearing.

During our study, the date of first egg laying varied between 2016 and 2017. It took place in the 3rd week of April in 2016 and the 3rd week of May in 2017. Between 1990 and 1992, it was recorded between the 1st and 4th week of April (Boumezbeur, 1993). Fouzari et al. (2015), Djelailia et al. (2017), Loucif et al. (2021) and Merzoug et al. (2014) situate it in mid-April at the same site, but Gherib (2018) estimates it between the 1st and 3rd week of April, depending on the year. Thus, it seems that the date of 1st laying recorded in 2016 agrees with that mentioned in various works at Lake Tonga and other wetlands in the country. However, the date in the 2nd study year was delayed by one month, which could be explained by the

fact that in 2017, the rainy period was extended, resulting in a late start to laying. Fiala (1966) mentions the delay in 1st egg laying after harsh winters. Various studies have reported the influence of external factors, in particular the action of climate on the avian physiology in relation to the development of the vegetation in relation to the availability of food resources necessary for the greatly increased energy requirements of females for laying initiation (Bezzel, 1969; Kux, 1963 and Havlin, 1966). Bezzel (1969) notes the slower rate of egg-laying and delayed onset of incubation due to unfavourable conditions.

Egg-laying period, which varied between 9 and 11 weeks during the present study, is generally consistent with that of studies carried out in the same wetland (Djelailia et al., 2017; Loucif et al., 2021) but seems slightly shorter than that of Boumezbeur (1993), 11 to 12 weeks, and slightly longer than that of Narsis et al. (2019) at Lake Tonga (8 weeks) and Merzoug (2015) at Garaet Hadj Tahar (6 to 7 weeks). Cramp and Simmons (1977) report duration of 8 weeks in the south of the Ferruginous Duck's range and 11 weeks in the north. Thus, it would appear that the laying period recorded at Lake Tonga during our work and that of other works at the same site is closest to the data provided for the north of the species' distribution area, suggesting the existence of a single laying period for both north and south.

In Lake Tonga, various average clutch sizes have been reported by several authors: Boumezbeur (1993): 9.38 eggs (between 1990 and 1992), Djelailia et al. (2017): 13.3 eggs; Narsis et al. (2019): 11 eggs and Loucif et al., (2021): 9.8 eggs. The egg-laying sizes recorded in this work appear to be identical to those of the aforementioned authors but smaller than those of others. However, they are larger than those of Merzoug (2015) at Garaet Hadj Tahar, probably because of the small sample size considered by this researcher.

Hatching success varied over both breeding seasons. The average values recorded during this work appear to be higher than those reported by Djelailia et al. (2017) and Loucif et al. (2021), as well as those noted by Merzoug (2015). However, these percentages seem less important than those reported by Boumezbeur (1993). These hatching rates, which fluctuate according to years and authors, would be due to factors reported in all studies carried out on the species in Lake Tonga particularly and other nearby wetlands, namely nest abandonment, predation, flooding or vandalism (egg pillaging) (Boumezbeur, 1993; Merzoug, 2015; Fouzari et al., 2015; Djelailia et al., 2017 and Loucif et al., 2021). Nest desertion or abandonment was the most important cause of failure noted in this study, in line with research carried out on the

same site (Djelailia et al., 2017 and Loucif et al., 2021). However, Merzoug (2015) and Fouzari et al. (2015) indicate that predation was the main cause of failure during their studies.

Two cases of interspecific parasitism were recorded; the intruder species was the Purple swamphen, which had laid 1 egg in each of the two Nyroca nests. This case of parasitism with this particular species was reported for the first time in this study. Boumezbeur (1993), Fouzari et al. (2015), Djelailia et al. (2017) and Loucif et al. (2021) had all mentioned other nests parasite species: White-headed Duck, Common Coot, Mallard and Common Moorhen. Lebedeva and Markitan (2001) reported in Azov region (Russia) the discovery of mixed broods consisting of of Ferruginous Duck and Mallard eggs, as well as those of Common Pochard, Common Moorhen and even Common Little Bittern. On the other hand, we assumed that a clutch size greater than 15 eggs constituted a case of intraspecific parasitism as indicated by Djelailia et al. (2017).

Concerning the distribution of the Ferruginous Duck at Lake Tonga, Lazli (2011) notes a significant occupation from March to June in Meizila area, then from July at the Mirador, which hosts the largest numbers of the species. In fact, from this date onwards, the banks of the lake are dried out and invaded by a large amount of vegetation, in particular the reedwort *Sparganium erectum*, and it is at the Mirador that most of the Nyroca population congregates, because of the beaches of water that remain unoccupied after the water has been invaded by the White Water Lily. Initial occupation of the banks before the Mirador corresponds to a choice made by the Nyrocas because of the richness in food provided in these places (Boumezbeur 1993, Lazli, 2011; Menasria and Lazli, 2017).

Conclusion

The fact that Lake Tonga is frequented by a representative population of the near-threatened Ferruginous Duck is the result of the site's excellent ecological values, which, among other things, allow nesting to occur smoothly in terms of both trophic levels and safety.

In Algeria, the species, which is listed in various national protection texts, remains relatively unknown and little research has been devoted to it, although it has a sedentary nesting status in the El Kala National Park wetlands and those of the country East region in general. However, research area remain little explored, in particular its diet, ethology, migration corridors and movements, etc.

Our study has enabled us to update the data on its breeding biology and is a valuable complement to previous studies initiated at the same site, especially those of Boumezbeur (1993) and Lazli (2011).

In view of climate change and consequences induced by this phenomenon, which is causing many changes in aquatic ecosystems functioning and integrity, any alteration of which could be at the origin of habitat fragmentation and decline of fauna in general, and avifauna in particular, action plans should be developed for the conservation of these particular environments and their biodiversity.

Acknowledgements

We would like to express our gratitude to all those who participated in any way in the completion of this work, particularly Mr Yahia Mecif, our friend "Ali Bouzana" who helped us in the search for nests and their identification, the owners of the boat, Abdo and Kamel Rezougue and especially Mr Abdesslem GRIRA, engineer at the El Kala National Park.

References

Abdellioui, S. (2017). Écologie des Grèbes et du Fuligule nyroca au niveau de Garaet Hadj-Tahar (Complexe de Guerbes-Sanhadja, Skikda, Nord-Est de l'Algérie). Thèse Doct. Univ. Larbi Ben M'Hidi, Oum El-Bouaghi. Algérie.

Abdi, S., Merzoug, S.E., Tabouche, K., Maazi, M.C. and Houhamdi, M. (2016). Structure des effectifs et stationnement hivernal du fuligule nyroca *Aythya nyroca* dans le complexe des zones humides de Guerbes-Sanhadja (nord-est algérien). *Bull. Soc. zool. Fr.*, 141 (2), 91-102.

Aissaoui, R., Houhamdi, M. and Samraoui, B. (2009). Eco-Éthologie des Fuligules nyroca *Aythya nyroca* dans le Lac Tonga (Site Ramsar, Parc National d'El-Kala, Nord-Est de l'Algérie). *European Journal of Scientific Research*, 28 (1), 47–59.

Aissaoui, R. (2012). Eco-éthologie des Anatidés dans la Numidie orientale : Cas de la Fuligule nyroca *Aythya nyroca* dans le Lac Tonga. Thèse Doct. Univ. Badji Mokhtar, Annaba. Algérie.

Ali, S. and Ripley, S.D. (1978). Handbook of the birds of India and Pakistan: Together with those of Bangladesh, Nepal, Bhutan and Sri Lanka. Vol. 1. Divers to Hawks. Second Edition. Delhi (India): Oxford University Press.

Atoussi, S. (2014). Etude des rythmes d'activités diurnes des fuligules hivernants dans Garaet Hadj Tahar (Skikda, Nord-est Algérien). Thèse Doct. Univ. 08 Mai 1945, Guelma. Algérie.

Ayaichia, F. (2018). Etude comparative du regime alimentaire des Canards du Lac Tonga, Nord-est algérien. Thèse Doct. Univ. 08 Mai 1945, Guelma. Algérie.

Bediaf, S., Benmetir, S., Boucheker, A., Lazli, A. (2020). Diversité de l'avifaune aquatique du marais de la Mekhada. Etat actuel et valeur patrimoniales d'un site Ramsar (Nord-Est Algérien). *Bull. Soc. zool. Fr.*, 145, 97-118.

Benmetir, S. (2021). Hivernage du Grand cormoran *Phalacrocorax carbo* dans les zones humides de la région d'El-Kala. Thèse Doct. Univ. Chadli Bendjedid, El Tarf, Algérie.

Bezzel, E. (1969). Die Tafelente (*Aythya ferina*). Wittenberg Lutherstadt: A. *Neue Brehm Bücherei/Ziemsen Verlag*.

BirdLife International. 2019. *Aythya nyroca*. *The IUCN Red List of Threatened Species* 2019: e.T22680373A152620862. https://dx.doi.org/10.2305/IUCN.UK.2019-3.RLTS.T22680373A152620862.en.

Boumezbeur, A. (1993). Ecologie et biologie de la reproduction de l'Erismature à tête blanche *Oxyura leucocephala* et du Fuligule nyroca *Aythya nyroca* sur le Lac Tonga et le Lac des oiseaux, Est algérien. Thèse Doct. Univ. Montpellier. France.

Cramp, S. and Simmons, K.E.L. (1977). The birds of the Western Palearctic. Vol I. Oxford. University Press, Oxford.

Djelailia, A. (2016). Ecologie de la reproduction du Fuligule nyroca *Aythya nyroca* au niveau du Lac Tonga, Nord-est de l'Algérie. Thèse Doct. Univ. 8 mai 1945. Guelma. Algérie.

Djelailia, A., Baaziz, N., Samraoui, F., Alfarhan, A. H. and Samraoui, B. (2017). Distribution and breeding ecology of the Ferruginous Duck *Aythya nyroca* in Algeria. *Ostrich*, 89, 5-12. DOI: 10.2989/00306525.2017.1313331

Draidi, K. (2014). Le Fuligule nyroca *Aythya nyroca* dans le Lac Tonga (Nord-est de l'Algérie). Étude du budget-temps, stratégie d'hivernage et étude de l'écologie parasitaire. Thèse Doct. Univ. Badji Mokhtar, Annaba. Algérie.

Etchecopar, R.D. and Hüe, F. (1964). Les oiseaux du nord de l'Afrique, de la Mer Rouge aux Canaris. Ed. Boubée, Paris.

Fiala, K.L. (1966). Ecothau. Synthèse des résultats- Archimer- Laboratoire Arago, Université P. M. Curie et U. A. CNRS 117, 66650… Faculté des Sciences de Montpellier. France.

Fouzari, A., Samraoui, F., Alfarhan, A.H. and Samraoui, B. (2015). Nesting ecology of Ferruginous Duck *Aythya nyroca* in north-eastern Algeria. *African Zoology*, 50 (4), 299-305. DOI: 10.1080/15627020.2015.1108165

Gherib, A. and Lazli, A. (2017). Les oiseaux d'eau nicheurs de l'Arboretum du Lac Tonga (Nord-est algérien). *Bull. Soc. zool. Fr.*, 142 (3), 119-142.

Gherib, A. (2018). Contribution à l'étude des oiseaux d'eau nicheurs de l'Arborétum du Tonga (Nord-est algérien). Thèse Doct. Univ. Chadli Bendjedid- El Tarf. Algérie.

Gherib, A., Lazli, A., Naili, S., Boucheker, A., Ikhlef, D. and Mechaka, N.I. (2021). Avifauna diversity and phenology in a Ramsar site: Lake Tonga (Northeastern Algeria). *Arxius de Miscel·lània Zoològica*, 19, 321–344. DOI: https://doi.org/10.32800/amz.2021.19.0321

Havlin, J. (1966). Breeding success of the Pochard and the Tufted Duck in Czechoslovakia. *Bird Study*, 13 (4), 306-310. DOI: 10.1080/00063656609476134

Heim De Balsac H. and Mayaud, N. (1962). Les oiseaux du Nord-Ouest de l'Afrique. Lechevalier. Paris.

Houhamdi, M. and Samraoui, B. (2008). Diurnal and nocturnal behaviour of Ferruginous Duck *Aythya nyroca* at Lac Des Oiseaux, Northeast Algeria. *Ardeola*, 55, 59–69. *doi: 10.2989/OSTRICH.2007.78.2.62.176*

Houmani, M. (2012). Ecologie du Fuligule nyroca (*Aythya nyroca*) dans le Nord-Est Algérien : Lac Tonga. Thése Magist. Univ. Badji Mokhtar-Annaba.

Hoyt, D. F. (1979). Practical methods of estimating volume and fresh weight of bird eggs. *Auk*, 96, 73-77. https://academic.oup.com/auk/article/96/1/73/5184694

Isenmann, P. and Moali, A. (2000). *Oiseaux d'Algérie*. Paris (France) : Société d'Etudes Ornithologiques De France.

Isenmann, P., Gaultier, T., El-Hili, A., Azafzaf, H., Dlensi, H. and and Smart, M. (2005). Oiseaux de Tunisie. Paris (France) : Société d'Etudes Ornithologiques De France.

Jamieson, I. G., Mc Rae, S.B., Simmons, R. E. and Trewby, M. (2000). High rates of conspecific brood parasitism and egg rejection in Coots and Moorhens in ephemeral wetlands in Namibia. *Auk*, 117, 250-255. DOI: 10.1093/auk/117.1.250

Kux, Z. (1963). Beitrag zur Kenntnis der Verbreitung and Bionomie der Enten-vogel (Anatidae) im Inundationsgebiet des Unterlaufs der Thaya and denanliegenden Teiche. *Acta Mus. Moraviae*, 48,167-208.

Lardjane-Hamiti, A., Metna, F., Merabet, S., Rakem, K., Boukhemza, M. and Houhamdi, M. (2013). Quelques aspects éthologiques du Fuligule nyroca Aythya nyroca (Anatidae) dans la réserve naturelle du lac de Réghaia (Algérie). *Bull. Soc. zool. Fr.*, 138 (1-4) : 103-113.

Lazli, A. (2011). *Contribution à la connaissance de l'écologie et de la biologie de reproduction de l'Erismature à tête blanche* Oxyura leucocephala *et du Fuligule nyroca* Aythya nyroca *au niveau du Lac Tonga*. Thèse Doct. Univ. Abderrahmane Mira, Béjaia (Algérie).

Lazli, A., Boumezbeur, A., Moali–Grine, N. and Moali, A. (2011a). Évolution de la population nicheuse de l'Érismature à tête blanche *Oxyura leucocephala* sur le Lac Tonga (Algérie). *Revue d'Écologie (la Terre et la Vie)*, 66, 173–181. DOI: 10.3406/revec.2011.1584

Lazli, A., Boumezbeur, A., Perennou, C. and Moali, A. (2011b). Biologie de la reproduction de l'Érismature à tête blanche *Oxyura leucocephala* au lac Tonga (Algérie). *Revue d'Écologie (la Terre et la Vie)*, 66, 255–265. DOI:10.3406/revec.2011.1596

Lazli, A., Boumezbeur, A. and Moali, A. (2012). Statut et phénologie de la reproduction du Fuligule nyroca Aythya nyroca au Lac Tonga (Algérie). *Alauda*, 80 (3), 219–228. http://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=26362514

Lazli, A., Benmetir, S., Bediaf, S., Mazni, S., Messai, Z. and Iboud, T. (2018). L'avifaune aquatique hivernante du lac Oubeira (Nord-est algérien). État actuel et intérêt patrimonial. *Alauda*, 86 (2), 95-108.

Lebedeva, N.V. and Markitan, L.V. (2001). Problems of Population Dynamics of the White-Eyed Pochard (Aythya nyrocaGuld., 1770) in the Eastern Sea of Azov Region. *Russian Journal of Ecology*, 32 (6), 425-431. DOI:10.1023/A:1012538302166

Loucif, K., Maazi, M.C., Houhamdi, M. and Chenchouni, H. (2021). Nest site selection and breeding ecology of the Ferruginous Duck (*Aythya nyroca*) in Algeria. *Global Ecology and Conservation*, (2020). https://doi.org/10.1016/j.gecco.2021.e01524

Lyon, B.E. (1993). Conspecific brood parasitism as a flexible female reproductive tactic: American Coots. *Animal Behavior*, 46, 911-928. https://doi.org/10.1006/anbe.1993.1273

Mc Rae, S.B. (1997). Identifying eggs of conspecific brood parasites in the field: a cautionary note. *Ibis*, 139, 701-704.

Mecif, F., Boucheker, A. and Lazli, A. (2020). Biologie de la reproduction du Grèbe huppé *Podiceps cristatus* au Lac Tonga (Nord–est algérien). *Bull. Soc. zool. Fr.*, 145 (3), 225–246.

Menasria, B. and Lazli, A. (2017). Quelques aspects de la sélection de l'habitat par l'Érismature à tête blanche *Oxyura leucocephala* sur le lac Tonga. *Alauda*, 85, 283-294.

Metallaoui, S. and Houhamdi, M. (2010). Biodiversité et écologie de l'avifaune aquatique hivernante dans Garaet Hadj-Tahar (Skikda, Nord-Est de l'Algérie). *Hydroécologie Appliquée*, 17, 1-16. DOI:10.1051/HYDRO/2010002

Merzoug, S. E., Amor Abda, W., Belhamra, M. and Houhamdi, M. (2014). Eco-ethology of the wintering Ferruginous Duck *Aythya nyroca* (Anatidae) in Garaet Hadj-Tahar (Guerbes-Sanhadja, Northeast of Algeria). *Zoology and Ecology*, 24 (4), 297–304. DOI:10.1080/21658005.2014.953800

Merzoug, S. E. (2015). Structure du Fuligule nyroca Aythya nyroca dans les zones humides du littoral Est de l'Algérie : Statut et description des habitats. Thèse Doct. Univ. Mouloud Mammeri, Tizi-Ouzou. Algérie.

Naili, S., Boucheker, A., Gherib, A., Djelloul, R. and Lazli, A. (2021). Seasonal variation in physicochemical characteristics and lead contamination of Lake Tonga and their effects on waterbird populations. *Ukrainian Journal of Ecology*, 11 (1), 03-112. doi:10. 15421/ 2021_15

Narsis, S., Grira, A., Ouakid, M. L. and Houhamdi M. (2019). Effective evolution and reproduction of the Ferruginous duck (*Aythya nyroca*) in Tonga Lake (Northeast of Algeria). *Eco. Env. & Cons.* 25 (4), 167-174.

Rizi, H., Rouag, R. and Ziane, N. (2019). Phénologie de l'hivernage et budget d'activités diurnes du Fuligule nyroca (*Aythya nyroca* Güldenstädt, 1770) au Lac Tonga (Nord-est algérien). *Bull. Soc. zool. Fr.*, 144 (3), 147-153.

Robinson, J.A. and Hughes, B. (2003). International Species Review: Ferruginous Duck *Aythya nyroca*. AEWA.

Saïfouni, A., Bellatreche, M. and Chebouti-Meziou, N. (2020). Identification et cartographie des habitats naturels du Lac Tonga (EL-Kala, Algérie). *Revue Agrobiologia*, 1999 -2009.

Thévenot, M., Vernon, J.D.R. and Bergier, R. (2003). *The Birds of Morocco*. British Ornithologists Union Checklist Series 20. Tring (England): British Ornithologists' Union. 626p.

Van Dijk, G. and Ledant, J.P. (1983). La Valeur Ornithologique des zones humides de l'Est algérien. *Biological Conservation*, 26, 215-226.

Zitouni, A., Tahar, A., Bouslama, Z. and Houhamdi, M. (2014). Premières données sur la structure et l'écologie des populations de la Foulque macroule *Fulica atra* (Rallidés) dans les zones humides de la région d'El-Kala (Nord-Est de l'Algérie). *Rev. Sci. Technol., Synthèse,* 28, 25-33.