https://doi.org/10.48047/AFJBS.6.15.2024.14768-14792

AFJBS
African Journal of Biological Sciences
Journal homepage: http://www.afjbs.com

Research Paper Open Access

Factors Predicting nesting Site Occupancy by Threatened Waterfowl: The Case of the White headed duck *Oxyura leucocephala* in North-East Algerian wetlands

***Meriem ABERKANE1 , Farah CHETTIBI3, Yassamine ABERKANE3, Youcef Islam BEZAZ1, Hichem KHAMMAR1, Moussa HOUHAMDI2**

[1] Laboratory of functional Ecology and Environment, LFEE,University of Oum El Bouaghi, B.P. 10 Oum El Bouaghi 04000, Algeria,

[2] Laboratory LBEE: Biology, Water and Environment, Faculty of Nature and Life Sciences and Earth and Universe Sciences, Department of Nature and Life Sciences, 8 May 1945 University, BP 401, Guelma 24000, Algeria

[3] University of Oum El Bouaghi, B.P. 10 Oum El Bouaghi 04000, Algeria,

Corresponding author e-mail: meriem.aberkane@univ-oeb.dz
phone:+213-799-227-796; fax: +213-32-563-185
Orcid ID: 0000-0003-1549-6363.

Volume 6, Issue 15, Oct 2024

Received: 15 Aug 2024

Accepted: 25 Sep 2024

Published: 21 Oct 2024

doi: 10.48047/AFJBS.6.15.2024.14768-14792

Abstract

The IUCN Red List categorically classifies the white-headed duck (*Oxyura leucocephala*) as an "endangered" palaearctic species. Algeria's wetlands, including the Lake of Tonga and the pond of Boussedra, host the highest number of this species in Algeria.

The objective of this study is to ascertain the probability of successful nesting for the white-headed duck (*Oxyura leucocephala*) in the North-East Algerian wetland, taking into account the influence of natural and urban site factors.

Consequently, this study considers these Algerian wetlands to investigate the White-headed Duck's reproductive ecology over the period of six seasons where outings were conducted on a biweekly basis to assess nesting characteristics. The parameters examined included nest construction, nest dimensions (inner and outer diameter, depth, height), water depth, clutch size, and the monitoring of hatching and hatching failure.

The study's findings highlight some differences in the date of the egg-laying, dimensions and size compared to the Constantine high plains in Algeria and European regions. It has also been demonstrated that the density of plants to hide the nests, and a relatively significant depth of water have a substantial impact on the choice of nesting sites. Therefore, this bird chooses sites far from sources of disturbance and sites where predation is relatively low. The sites selection by the White-headed duck is similar to the Ferruginous duck.

The data outlines a low breeding success caused by a high rate of breeding failure in the egg stage due to natural predation at the pond of Boussedra and abandonment of nests at the lake of Tonga.

Key words: White-headed duck, Reproduction, phenology, urban wetlands, Boussedra, Algeria

Introduction

One of the seven nations with a significant number of White-headed ducks throughout the years is Algeria, where the species is legally protected. The resident population is found in the wetland complex of El Kala at Lake Tonga in the extreme northeast of the country (Isenmann and Moali., 2000; Lazli, 2011; Attoussi,2017).

The White-headed duck *Oxyura leucocephala*'s population has significantly decreased throughout the world in the 20th century. Consequently, it is now listed as "vulnerable" and "endangered" at the European and global levels (Birdlife International 2023), and it is protected under Algerian law as an endangered species (Lazli et al., 2011; Cettibi et al., 2013; Halassi et al.,2016; Attoussi et al., 2017; Hennouni et al., 2021). Known both as a sedentary breeder and as a winterer (Merzoug et al., 2021), it’s population was very common in the 19th century in the North-East (Lake Tonga, Lake Oubeira, Lake of the Birds, Mekhada marshes), in Boughzoul, wilaya of Médéa, since then, (Isenmann et Moali., 2000 ; Metallaoui et al., 2009; Houhamdi et al., 2009; Samraoui et al., 2011; Lazli et al., 2011 and 2012; Chettibi et al., 2013; Halassi et al.,2016; Attoussi et al., 2017; Oudihat et al.,2017; Hennouni et al., 2021 and Merzoug et al.,2021) have cited and studied the species in several localities such as: Garaet Hadj-Tahar, and in the highlands, Sebkhas of Tazoughart, Garaet of Timerganine, lake of Boulehilet. Its presence has also been noted on other sites: oued Seguin (Mila), Dayet El Ferd (Tlemcen), Ourkis reservoir (Oum El-Bouaghi) and the natural reserve of the lake of Réghaia (Algiers) (personal observations). There is still much to be discovered regarding this species and its reproductive patterns and spatial distribution in both the wetlands of Numidia and the high plains. Only a few studies have been dedicated to this topic thus far.

Assessing the status of waterfowl and the ecological state of the wetlands they occupy will allow for the development of conservation strategies by examining how they react to different environmental changes and keeping an eye on their phenological status. (Aouadi A, 2022)

The present work forms part of an evaluation strategy for protection purposes, with a dual objective:

- To maintain a record of the phenology and reproductive biology of the White-headed Duck in the wetlands of north-eastern Algeria.

- To gain insight into its preferences and its different spatial and temporal distribution and adaptation patterns across two distinct wetland types.

-Provide more detailed data concerning brood characteristics

1. Materials and methods

1.1. Study area

The study was led at two ecologically and geomorphologically different sites situated in the extream north Est of Algeria;

1. Tonga Lake (latitude 36° 53, N, longitude 08° 31, E), located in the far northeast corner of Algeria, near the Algerian-Tunisian border. The lake is designated as a wilderness area within the National Park of El Kala and classified as a Ramsar site of international importance since 1982 (Fig. 1). Tonga Lake covers a total area of about 2600 ha. It is a freshwater marsh, which communicates with the sea via the man-made channel of Messida. The water body is rich in helophytes and emergent plants (*Nymphaea Alba* and *Potamogetonpectinatus*) covering during the breeding season, 80% of its surface (Aissaoui et al., 2011; Lazli et al., 2011; Loucif et al.,2021).

2. Our study was also carried out at Boussedra (36°50'40.88"N, 7°43'37.30"E), a lentic unprotected freshwater marsh in Northeast Algeria, in a 55-ha area, having lost more than 50% of its former area up until 2010, also surrounded by residential areas. It is renowned for the richness and the high productivity of its waterbirds population, and it is home to sizable wintering and breeding populations of rare waterbirds such the ferruginous duck (*Aythya nyroca*) and white-headed duck (*Oxyura leucocephala*) (Boudraa et *al*., 2014; Hennouni M.A, 2024). *Scirpus maritimus, S. australis,* and *Phragmites australis* represent the majority of the vegetation in Boussedra (Draidi et *al*., 2023). The climate is typically Mediterranean, with a long dry season from March to September and a brief wet season from October to February (Aouadi et *al*., 2021). The region's average annual temperature is 17.7 °C (14.7–20.7 °C), and it rarely gets below zero degrees Celsius. It also experiences a higher level of precipitation than most other regions of North Africa, with an average annual rainfall of 1300 millimeters. (Loucif et *al*., 2024).

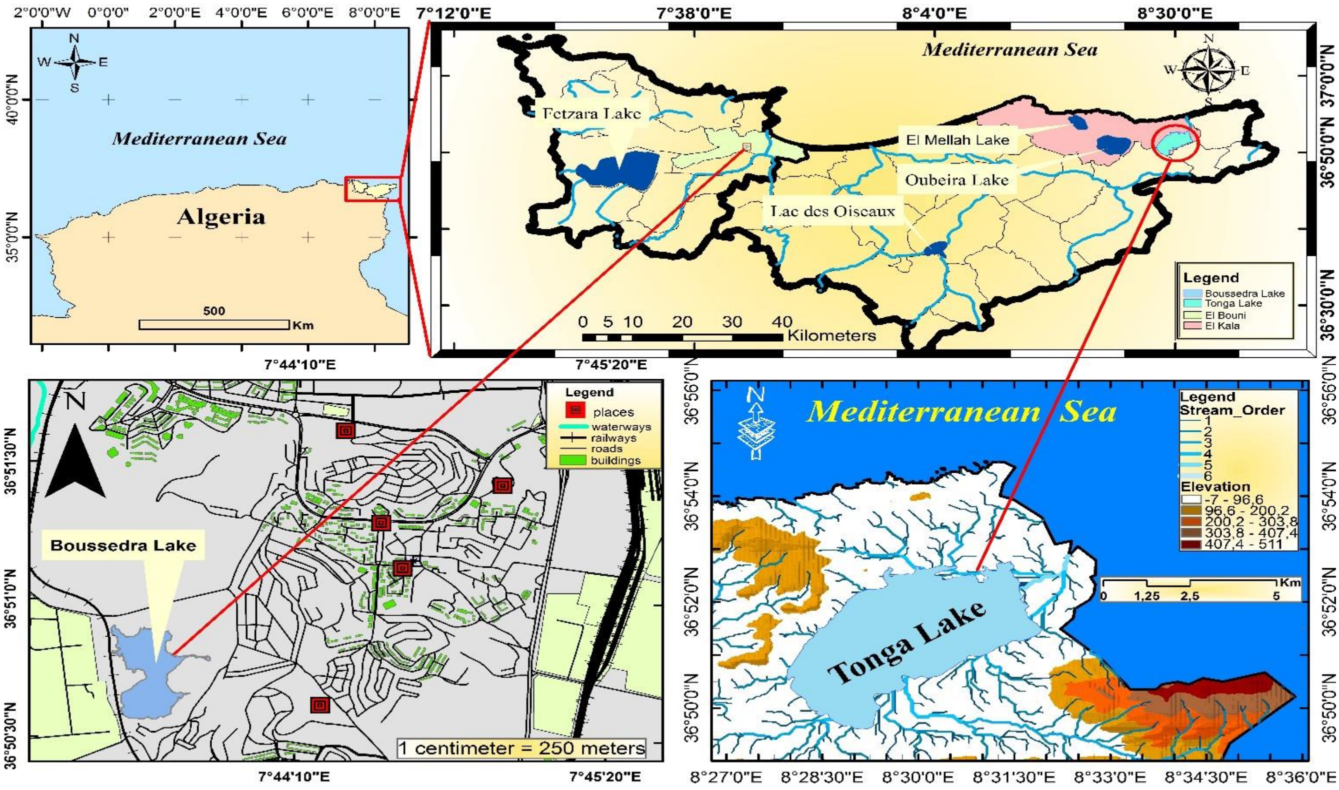

Fig.1: Geographical location map of the study area.

Fig.2. Nesting couples of white-headed duck at Boussedra marsh

1.2. Data collection

Data used for our work covers six years period from 2012 to 2018. Outings were arranged twice a week to measure nesting characteristics.

The parameters taken into account can be summed up as follows: nest building, nest measurements (inner and outer diameter, depth, heightening), water depth, clutch size as well as the monitoring of hatch and hatch failures (predation and abandonment). The volume of eggs was calculated using the following formula: 0.476.L.12/1000 or (L): great length and (1): great width of eggs (Harris, 1964).

1.2. Data analysis

For the statistical analysis, we took into consideration the data from the first two seasons, which we believe to be the best characterized, when breeding numbers were highest and water levels were stable.

Descriptive statistics are employed for summarizing the data pertaining to each parameter.
Statistical analysis was carried out and performed using software SPSS 27; using Linear Regression, we examined the effect of different factors on nest success, One way and Two way MANOVA To assess the relationships and interaction between considered parameters.

2. Results and discussion

Of the hundred or so nests recorded during the study period, only 71 were accessible for measurement and characterization, 41 in Boussedra and 30 in Tonga. Of these 71 nests , 33.8% (n = 24) were predated, 18.3% (n = 13) were deserted and 47.9% (n = 34) yielded at least one chick.

Results obtained at the two study sites were compared with studies conducted across certain regions of the white-headed duck nesting areas.

2.1. Nest locations

The white-headed duck at both study sites-built nest in emergent vegetation but not on dry land. Only one nest was built on small islet. Nests were built in few plant species; most of them were located in *Typha angustifolia*

The average distance from the closest mainland was 99.8 ±12.2 m. The closest nest was within a range of 16.0 ± 4.2 m. At both nest sites, the mean water depth was 76.3 ± 4.0 cm. 16.4 ± 3.5 m was the average distance to the open water (Table.1).

Table 1. Interaction between nest site selection factors

Variables	Total				Boussedra		Tonga		Successful		Unsuccessful	
	Mean	SE	Min	Max	Mean	SE	Mean	SE	Mean	SE	Mean	SE
ENCD	29,92	,57	20,0	41,0	30,28	,73	29,43	,92	31,33	,86	28,62	,70
INCD	17,84	,53	8,0	30,0	18,37	,64	17,10	,91	18,80	,76	16,94	,73
NCD	8,25	,40	2,0	19,0	8,661	,48	7,70	,68	9,31	,53	7,28	,55
NH	3,08	,65	0	20	2,83	,95	3,43	,83	2,97	,91	3,19	,9
WDN	76,34	4,005	0	150	71,29	3,53	83,23	8,07	76,26	5,32	76,41	6,0
DNN	15,99	4,24	,5	200,0	3,72	,41	32,76	9,25	10,72	5,84	20,83	6,07
DNM	99,85	12,17	4	500	77,44	9,71	130,47	24,74	97,21	17,48	102,27	17,17
DNOP	16,38	3,54	,0	120,0	7,34	2,03	28,75	7,41	11,66	4,44	20,73	5,40
SH	2,438	,067	,50	3,35	2,42	,10	2,46	,08	2,34	,10	2,52	,08
SV	37,18	3,04	0	100	40,73	4,32	32,33	4,03	42,06	4,92	32,70	3,60
NC	30,63	3,17	0	100	26,59	4,08	36,17	4,91	22,21	3,44	38,38	4,90
VD	61,55	2,95	10	100	63,29	3,82	59,17	4,66	67,35	4,15	56,22	4,02

ENCD, external nest cup diameter; INCD, internal nest cup diameter; NCD, cup depth; NH, nest height above water; WDN, water depth at the nest; DNN, distance to nearest nest; DNM, distance to nearest mainland; DNOP, distance of nests from the open water; SH, substrate height; SV, sec vegetation around nests; NC, nest concealment; VD, vegetation density.

Nests built in Boussedra were significantly closer to each other, adjacent to the nearest mainland and closer to the open water than those in Tonga, and the mean distance to the mainland was highest in 2013 (Tab. 1 and 2). Only the mean distance to the open water differs significantly between months, years and sites (Table.1 and 3).

Table 2. Interaction between site and year factors

Variables	Boussedra/Tonga		2012/2013		Successful/Unsuccessful	
	F	*P*	F	*P*	F	*P*
ENCD	0.530	0.469	0.469	0.496	6.011	0.017
INCD	1.387	0.243	9.671	0.003	3.086	0.083
NCD	1.413	0.239	0.016	0.899	6.940	0.010
NH	0.208	0.650	0.234	0.630	0.028	0.868
WDN	2.206	0.142	3.951	0.051	0.000	0.986
DNN	13.489	0.000	0.067	0.796	1.429	0.236
DNM	4.889	0.030	7.021	0.010	0.043	0.837
DNOP	10.037	0.002	0.441	0.509	1.646	0.204
SH	0.097	0.756	0.462	0.499	1.909	0.172
SV	1.881	0.175	1.182	0.281	2.406	0.125
NC	2.269	0.137	0.075	0.785	7.057	0.010
VD	0.474	0.493	2.677	0.106	3.695	0.059

ENCD: external nest cup diameter; **INCD:** internal nest cup diameter; **NCD:** cup depth; **N:** nest height above water; **WDN:** water depth at the nest; **DNN:** distance to nearest nest; **DNM:** distance to nearest mainland; **DNOP:** distance of nests from the open water; **SH:** substrate height; **SV:** sec vegetation around nests; **NC:** nest concealment; **VD:** vegetation density

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No significant interaction of those variables between site and year factors was recorded (Two way MANOVA; Wilks' λ= 0.946, $F_{4.64}$ = 0.912; P = 0.463), but they differ significantly between the two sites (Two way MANOVA; Wilks' λ= 0.495, $F_{4.64}$ = 16.308; P < 0.0005), and over the two years (Two way MANOVA; Wilks' λ= 0.654, $F_{4.64}$ = 8.460; P < 0.0005). Further, all of these characteristics varied significantly according to substrate species in which nests were built (One way MANOVA; Wilks' λ= 0.297, $F_{24.214}$ = 3.713; P < 0.0005) (Table. 4).

Table. 3 Interaction between sites, year and date of laying factors

Variables	DNM		DNN		WDN		DNOP	
	F	*P*	F	*P*	F	*P*	F	*P*
Months	6.314	0.003	.668	0.516	1.596	0.211	3.790	0.028
Sites	4.147	0.046	8.057	0.006	2.408	0.126	13.968	0.000
Years	1.540	0.219	0.006	0.938	2.530	0.117	3.755	0.057
Months x Sites	4.072	0.048	1.414	0.239	0.875	0.353	3.120	0.082
Months x Years	0.857	0.429	0.17	0.984	1.617	0.207	3.447	0.038
Sites x Years	0.210	0.648	0.001	0.978	0.156	0.694	1.348	0.250
Months x Sites x Years	1.057	0.308	0.076	0.784	2.346	0.131	4.896	0.031

DNM, distance to nearest mainland; DNN, distance to nearest nest; WDN, water depth at the nest; DNOP, distance of nests from the open water.

Table. 4 Interaction between nest factors and species used to build nests

Variables	*Typha angustifolia*			*Scirpus maritimus*			*Typha angustifolia* and *Salix pedicellata*			*Scirpus lacustrus*		
	N	Mean	SE	N	Mean	SE	N	Mean	SE	N	Mean	SE
DNM	46	108.28	12.83	10	71.80	47.80	4	155.00	50.74	8	41.88	9.44
DNN	46	13.130	3.59	10	14.25	9.56	4	88.75	50.83	8	3.00	.72
WDN	46	82.50	4.30	10	45.50	8.11	4	101.25	22.20	8	66.88	11.13
DNOP	46	8.57	2.94	10	31.25	9.85	4	1.50	.84	8	41.25	15.66

DNM: distance to nearest mainland; **DNN:**distance to nearest nest; **WDN:** water depth at the nest; **DNOP:** distance of nests from the open water.

Moreover, substrate height, nest height and substrate species were related to egg-laying date (One way MANOVA; Wilks' λ= 0.817, $F_{6.132}$ = 2.342; P = 0.035), and site (One way MANOVA; Wilks' λ= 0.701, $F_{3.67}$ = 9.524; P < 0.0005). Each year, substrate height and nest height varied according to substrate species (One way MANOVA; Wilks' λ= 0.570, $F_{8.54}$ = 2.187; P = 0.043; Wilks' λ= 0.551, $F_{8.64}$ = 2.773; P = 0.011; 2012 and 2013 respectively).

To assess the relationships among those variables, we regressed substrate height and nest height on egg-laying date. Egg-laying date illustrated variation in substrate height (Linear Regression; R^2 = 0.194, $F_{1.69}$ = 16.561; P < 0.0005) and nest height (Linear Regression; R^2 = 0.090, $F_{1.69}$ = 6.865; P = 0.011).

Nest concealment, vegetation density and sec vegetation around the nest were not related to egg-laying date (One way MANOVA; Wilks' λ= 0.885, $F_{6.132}$ = 1.388; P = 0.224), site (One way MANOVA; Wilks' λ= 0.943, $F_{3.67}$ = 1.347; P = 0.267) and year (One way MANOVA; Wilks' λ= 0.944, $F_{3.67}$ = 1.335; P = 0.270). In contrast, those variables varied significantly according to substrate species (One way MANOVA; Wilks' λ= 0.576, $F_{18.175}$ = 2.100; P = 0.008).

According to Johnsgard and Carbonell,1996, the White headed duck generally chooses large lakes bordered by large, dense strata of emergent vegetation and small closed pools in a large wetland complex. White headed ducks are best suited to life in marshes with small open pools and a depth of 0.5-3m.

Typha angustifolia, Scirpus lacustris, Scirpus maritimus, and *Phragmite australis* are extensive and dense plant stratum that are found in Lake Tonga and Boussedra Pond and have a depth of 2 meters.

Tracking distribution of White-headed duck through Lake Tonga revealed that areas between the old school and alder (west) are the most favorable areas for the species.(Lazli,2011) and (Hennouni,2021) noted the same distribution and habitat selection by this anatidae. This region of the lake is recognized by dense strata of emergent vegetation. It is assumed that either this area of the lake meets the needs of the species during the breeding season, or that competition or the dominance system would be associated with these birds in less favorable areas.

The Boussedra Pond has less heterogeneity than Lake Tonga, we observe that *Typha angustifolia* predominates in the emergent marsh vegetation, and there are a few areas of open water, thus the oxyuras have chosen dense plots to build their nests.

The depth of water and density of vegetation strata therefore have an impact on nest site selection. Smaller strata may be exposed to a higher risk of predation due to a larger edge effect (Moller, 1991; Hoover et al., 1995). White-headed duck may directly or indirectly assess the quality of an environment and the risk of predation when selecting nesting sites (Martin, 1993). Nest predation may also vary between strata and between areas. We found that *Scirpus maritimus* predicted reproductive failure. It has been noted that in the western part of Boussedra pond the predation rate of nests of all species is very high. the predation rate of Fuligule nyroca *Aythya nyroca* nests is higher in islets of vegetation than in alder and emerging vegetation.

In our study, no relationship was found between predation rate and nest/bank distance. The most important factors that determine the selection of nesting sites by the White-headed duck in Erçek Lake, Arin Lake, and Norşin Lake were height of emerging vegetation, nest elevation relative to water surface, nest/bank distance, and nest/open water distance. The height of the emerging vegetation, the elevation of the nest in relation to the water's surface, the distance between the nest and a berge, and the distance between the nest and open water all had an impact on nest preference (Nergiz et al., 2013).

2.2. Nest characteristics

Both internal cup diameter and nest cup depth of nests increased as the external diameter increased, and only the external diameter of nests decreased as nest height increased.

The distance to the open water decreased as both water depth and the distance to the nearest mainland increased. In contrast, the distance to the nearest nest was highly correlated with water depth and the distance to mainland. Moreover, the distance to the nearest nest increased as the distance to the mainland increased.

The dry vegetation around the nest was positively correlated with water depth and negatively with both plant height and vegetation density. Also, vegetation density was positively correlated with plant height. In addition, nest concealment was highest as vegetation density was (Table.5).

Table. 5 Nest characteristics correlations

Variables	ENCD	INCD	NCD	NH	WDN	DNN	DNM	DNOP	SH	SV	NC	VD
ENCD	1	0.601**	0.308**	-0.279*	0.060	-0.044	0.139	-0.120	-0.226	-0.031	-0.122	0.051
INCD		1	0.268*	-0.107	-0.151	-0.122	-0.101	-0.070	-0.087	-0.094	0.035	0.139
NCD			1	-0.107	-0.054	0.027	0.013	0.016	-0.067	0.004	0.062	0.143
NH				1	0.017	-0.037	-0.155	0.125	-0.195	0.095	0.159	-0.018
WDN					1	0.371**	0.522**	-0.438**	-0.168	0.321**	0.129	-0.090
DNN						1	0.526**	-0.177	-0.174	0.124	-0.147	-0.155
DNM							1	-0.366**	-0.192	0.069	0.002	-0.051
DNOP								1	0.136	-0.231	-0.216	-0.076
SH									1	-0.294*	0.066	0.280*
SV										1	0.028	-0.245*
NC											1	0.663**
VD												1

ENCD: external nest cup diameter; **INCD:** internal nest cup diameter; **NCD:** cup depth; **NH:** nest height above water; **WDN:** water depth at the nest; **DNN:** distance to nearest nest; **DNM:** distance to nearest mainland; **DNOP:** distance of nests from the open water; SH: substrate height; **SV:** dry vegetation around nests; NC: nest concealment; **VD:** vegetation density**.**

Oxyura nests are constructed from materials collected in the immediate vicinity of the nests, of the same type of vegetation as their supports. In a similar study of the *Fulica atra* coot, nest sizes were related to vegetation strata (Samraoui and Samraoui, 2007; Rizi, 2018) indicates that nests constructed from rigid material such as phragmites have a larger outer diameter. Most of the Stirrup nests on Lake Tonga and Boussedra pond are constructed from *Typha angustifolia*, *Scirpus maritimus* and *Scirpus lacustris*. Our study did not reveal a relationship between outer diameter and vegetation strata. In the Arin, Ercek and Norşin lakes in Turkey, nests are also constructed of stems and leaves of emerging vegetation around the nest (Nergiz et al., 2013).

A review of the literature on the white-headed duck indicates that it utilizes the nests of other waterfowl species, including the macro coot *Fulica atra* and the duckling duck *Aythya fuligula*. Generally, white headed duck repair nests with stems and leaves of emerging vegetation such as *Phragmite australis* and *Typha angustifolia*, other materials such as feathers have never been found in nests of this species (Johngard and Carbonell, 1996; Nergiz et al., 2013).

Our results confirm what Carbonell reported: some individuals covered their nests with leaves and some with down. In addition, the females can form a roof over the nest by folding down the leaves (Johnsgard and Carbonell 1996).

2.3. Date and period of laying

The spawning period for White-headed duck was 12 weeks (80 days) from early April to late June with a spawning peak (n = 22; 31%) during the second half of May (Fig. 3) . The average lay date is May 20 (49.93 days), which varies between May 2 and June 8.

There is no significant difference between the laying dates (One way Anova: $F_{1.69}=2.721$; $P = 0.104$). However, this value masks a clear spatial variability. When each site is treated separately, the difference is still not significant at Lake Tonga (One way Anova: $F_{1.28} = 0.036$; $P = 0.852$), but it is highly significant at Boussedra pond (One way Anova: $F_{1.39} = 6.018$; $P = 0.019$), the first season is the earliest.

N.B. an active nest contains at least one egg.

A significant difference was observed between laying dates at both sites (One way Anova: F 1.69 = 10.761; P = 0.002), the difference was significant in 2012 but not in 2013 (One way Anova: F 1.31 = 13.455; P = 0,001; F 1.36 = 2.144; P = 0.152 respectively).

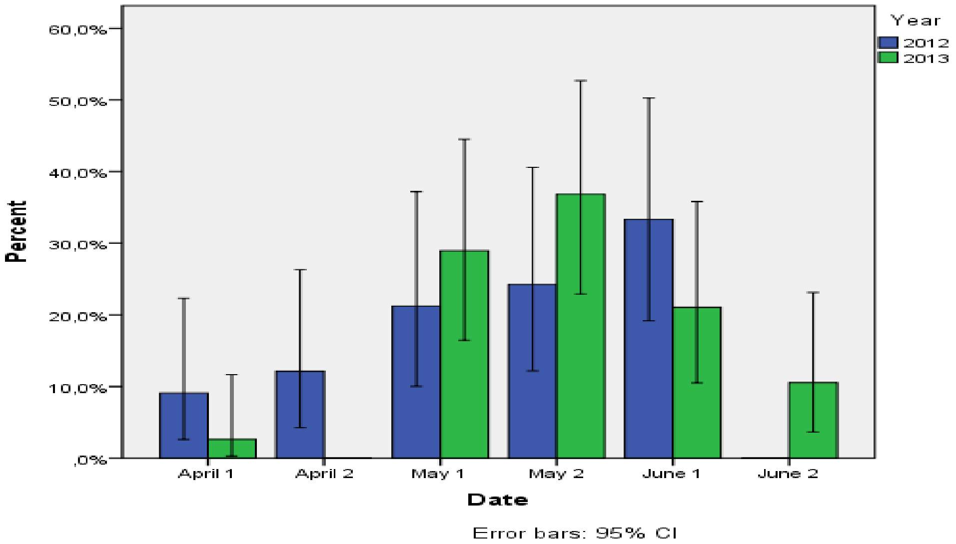

Fig 3. White-headed Duck spawning dates at Lake Tonga and Boussedra Marsh

During 2012, there was a significant difference in the laying dates of the two sites. Laying on Boussedra pond is earlier, which may be due to early availability of nesting sites. The vegetation of the previous year, which is rich in the pond, is crucial in the choice of nesting sites (Sage 1969; Blums 1973). The vegetation cover of the Boussedra pond is important compared to Lake Tonga (vegetation of the previous year), as well as the emerging vegetation grows in the Boussedra pond before Lake Tonga.

In 2013, the difference was not significant between the two sites. As ambient temperature can significantly influence the phenology of bird reproduction, the weather from 2013 to early April is probably the cause of the late laying on the Boussedra pond during this year.

The spawning dates recorded in Europe are also different from those recorded during this study; in Spain the laying takes place between the end of May and the beginning of July (Jiménez, 1994; Hughes and Green, 2005). In Turkey from mid-June to July-August (Kirwan et al., 2008). Laying occurs early in the wetlands of the far northeastern Algerian region compared to other nesting areas, which could be because good nesting sites became available early. The appropriate climatic conditions and the presence of trophic resources may be to blame for this; the laying date is controlled by genetic and environmental factors (Blondel et al., 1990).

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The dates of recorded lay-offs are similar to those recorded by Boumezbeur (1993) and Lazli (2011) in the years 1991, 1993, 2006, 2007, 2008. (Lazli, 2011)

2.4. Laying size

The mean laying size of the White-headed duck is 6.31 ± 0.35 (SD = 2.22; n=39) eggs/brood, range from 3 to 11 eggs/brood (Fig 4.).

There is no significant difference between the two seasons (Mann-Whitney U-test, z = - 0,313; P = 0.771) and the two study sites (Mann-Whitney U-test, z = - 0.756; P = 0.449).

N.B. Nests affected by conspecific parasitism as well as predatory nests and abandoned nests before the brood was complete were excluded from statistical clutch size analyzes.

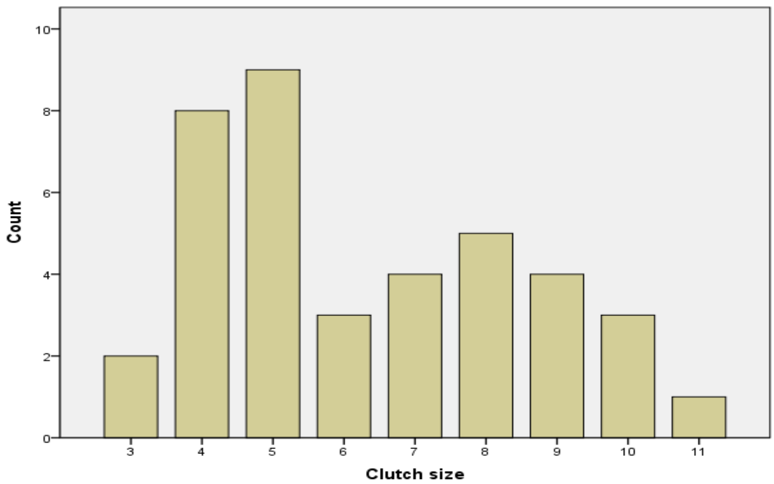

Fig. 4. Laying size of the white headed duck

The average laying size in Europe is 6 eggs [4-9] (Jimenez 1994; Johnsgard and Carbonell 1996; Hughes and Green 2005; Green et al 2002). The difference between Europe and the Boussedra-Lake Tonga pond complex is not significant; average (Kruskal-Wallis) H = 4,00; dll = 2; P = 0,135) min (Kruskal-Wallis; H = 4,00; dll = 2; P = 0,135) max (Kruskal-Wallis; H = 4,00; dll = 2; P = 0.135).

The average laying size measured by Houhamdi et al (2009) in the Southern High Plains of Constantine is 14 eggs [11-15] in Garaet Timerganine, 13 eggs [11-14] in Garaet Ouled M'barek, 15 [14-16] Garaet Ouled uled Amara and 13 [11-14] in Chott Tinsilt.

The difference between the High Plains and the Boussedra-Lake Tonga pond is significant, medium (Kruskal-Wallis; H = 6.222; dll = 2; P = 0.045), min (Kruskal-Wallis; H = 6.462; dll = 2; P = 0.040), max (Kruskal- Wallis; H = 6.222; dll = 2; P = 0.045).

Laying size is negatively and highly influenced by laying date, decreasing during the season (r= - 0.306; P = 0.009). It is highly influenced also with the disturbance (r = - 0.386; P = 0.001), but it is positively and significantly influenced with vegetation density (r = 0.237; P = 0.04), dry vegetation (r = 0.244; P = 0.04) and nest size; outer diameter (r = 0,361; P = 0,002), internal diameter (r = 0.308; P = 0.009) and depth (r = 0.537, P = 0.0005).

The average laying size in Europe is 6 eggs [4-9] (Johnsgard and Carbonell, 1996; Green et al., 2002). The difference between Europe and the Boussedra-Lake Tonga pond complex is not significant; average (Kruskal-Wallis) H = 4,00; dll = 2; P = 0,135) min (Kruskal-Wallis; H = 4,00; dll = 2; P = 0,135) max (Kruskal-Wallis; H = 4,00; dll = 2; P = 0.135).

The average laying size measured by Houhamdi et al (2009) in the Southern High Plains of Constantine is 14 eggs [11-15] in Garaet Timerganine, 13 eggs [11-14] in Garaet Ouled M'barek, 15 [14-16] Garaet Ouled uled Amara and 13 [11-14] in Chott Tinsilt.

The difference between the High Plains and the Boussedra-Lake Tonga pond is significant, medium (Kruskal-Wallis; H = 6.222; dll = 2; P = 0.045), min (Kruskal-Wallis; H = 6.462; dll = 2; P = 0.040), max (Kruskal- Wallis; H = 6.222; dll = 2; P = 0.045).

Laying size is negatively and highly influenced by laying date, decreasing during the season (r= - 0.306; P = 0.009). It is highly influenced also with the disturbance (r = - 0.386; P = 0.001), but it is positively and significantly influenced with vegetation density (r = 0.237; P = 0.04),

dry vegetation (r = 0.244; P = 0.04) and nest size; outer diameter (r = 0,361; P = 0,002), internal diameter (r = 0.308; P = 0.009) and depth (r = 0.537, P = 0.0005).

2.5. Nesting success

Using Linear Regression, we examined the effect of four different factors on nest success. Three factors were predicted nesting success, nest size (Linear Regression; $R^2 = 0.08$, $F_{1.69} = 6.011$; P = 0.017), nest concealment (Linear Regression; $R^2 = 0.09$, $F_{1.69} = 7.057$; P = 0.01) and the presence of the Ferruginous Duck nests at close proximity (Linear Regression; $R^2 = 0.28$, $F_{1.69} = 6.048$; P = 0.016). In contrast, the use of *Scirpus maritimus* as nest substrate predict nesting failure (Linear Regression; $R^2 = 0.307$, $F_{1.69} = 7.184$; P = 0.009).

Table.6. Effect of different factors on white-headed duck's nest success

Variables	Boussedra/Tonga		2012/2013		Successful/Unsuccessful	
	F	*P*	F	*P*	F	*P*
ENCD	0.530	0.469	0.469	0.496	6.011	0.017
INCD	1.387	0.243	9.671	0.003	3.086	0.083
NCD	1.413	0.239	0.016	0.899	6.940	0.010
NH	0.208	0.650	0.234	0.630	0.028	0.868
WDN	2.206	0.142	3.951	0.051	0.000	0.986
DNN	13.489	0.000	0.067	0.796	1.429	0.236
DNM	4.889	0.030	7.021	0.010	0.043	0.837
DNOP	10.037	0.002	0.441	0.509	1.646	0.204
SH	0.097	0.756	0.462	0.499	1.909	0.172
SV	1.881	0.175	1.182	0.281	2.406	0.125
NC	2.269	0.137	0.075	0.785	7.057	0.010
VD	0.474	0.493	2.677	0.106	3.695	0.059

ENCD: external nest cup diameter; **INCD:** internal nest cup diameter; **NCD:** cup depth; NH: nest height above water; **WDN:** water depth at the nest; **DNN:** distance to nearest nest; **DNM:** distance to nearest mainland; **DNOP:**distance of nests from the open water; **SH:** substrate height; **SV:** sec vegetation around nests; **NC:** nest concealment; **VD:** vegetation density.

Hatching success in both sites was less important than in other waterfowl at the same sites, such as the Purple swamphen *Porphyrio porphyrio*. The nests of the purple swamphen are higher than the nests of *Oxyura leucocephala* and are therefore inaccessible to aquatic predators, she ponds earlier compared to the white-headed duck. The percentage of predation increases towards the end of the breeding season (Loman, 1982) and since the males of *Oxyura leucocephala* are polygamous, they invest less in reproduction. This is presumed to explain the lower hatching success of this anatidae.

2.6. Reproductive failure factors

71 of the nests monitored, 13 were abandoned (18.3%) and 24 were predated (33.8%)

In the western part of Boussedra marsh near the slums, several breeding sites of Black Rats *Rattus rattus* were found. (Table.7)

Table.7. Factors of reproductive failure for White-headed Duck.

	Frequency	Percent	Valid Percent	Cumulative Percent
Deserted	13	18.3	18.3	18.3
Success	34	47.9	47.9	66.2
Predated	24	33.8	33.8	100.0
Total	71	100.0	100.0	

2.7. Conspecific and interspecific parasitism

A remarkable natural history occurrence that sheds light on the coevolution of hostile interactions is brood parasitism. There is still much to learn about the ecological and evolutionary aspects of brood parasitism, and new hosts for these parasites are always being found. (Williamson and Baumann, 2021).

A total of nine nests were identified as instances of conspecific parasitism, while five nests exhibited evidence of interspecific parasitism. These observations were made during the study at Lake Tonga and the Boussedra march among the nests (Fig. 5). The species involved in these instances of parasitism included the white-headed duck, the ferruginous duck, the marbled teal, and the common coot.

Fig 5 White-headed Duck's nest containing twenty two eggs.

The extensive range of environmental conditions observed at multiple stations illustrates the remarkable adaptability of this species to its diverse habitats. Indeed, the composition and current organization of Lake Tonga have facilitated the growth of the white-headed duck population. The population's utilization of resources is not constrained, and there has been a relative tranquil period since the country-wide prohibition on hunting. This unquestionably has been the driving force behind the species' population growth over the past twenty years and since Boumezbeur's initial study in 1991–1992.

While the Boussedra marsh is relatively small, its proximity to several disturbance factors, as well as the low quality of its water (Boudraa, 2015), may present challenges. However, the presence of the white-headed duck in this delicate ecosystem as a threatened species is a conservation argument that is worthy of consideration.

We discovered a phenomenon hitherto unknown in Algeria and rarely described for the White-headed Duck elsewhere: a comparatively high rate of interspecific and conspecific parasitism, particularly on the Boussedra Pond. This is likely due to the high nest density and heavy predation by the Viperine snake *Natrix maura* and the Black Rat *Rattus rattus.*

Conclusion

This study indirectly raises the issue of wetland management and natural resource preservation. In Lake Tonga, the issues of hunting, disturbance, poaching, and the hydrology of the lake (maintaining a stable water level) require urgent and comprehensive investigation.

Additionally, the implementation of a regulatory framework that organises the various activities at the lake and respects the avifauna is essential. It would be prudent to afford the Boussedra pond legal protection, at least until it is classified as a Ramsar site.

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