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Diurnal activity budget and breeding ecology of the White-headed Duck *Oxyura leucocephala* at Lake Tonga (North-east Algeria)

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The White-headed Duck *Oxyura leucocephala* is one of the most threatened duck species in the world. In the last decade ecology, behaviour and breeding biology of this species attracted considerable scientific interest across its geographic range. In order to fill some gaps in the knowledge of North African populations, diurnal and seasonal activity budget and breeding ecology of the species were investigated at Lake Tonga (Ramsar site), El Kala, Algeria. The species is resident at this site and its numbers were the highest in January. Throughout the year, ducks spent the following proportion of time on these activities daily: 62.41% resting, 18.50% locomotion, 11.04% feeding, 5.56% preening, 0.53% flying, 0.13% agonistic behaviour and 1.83% courting. Substantial differences were noted in the activity budget between wintering and breeding seasons. Resting and locomotion constituted 89% of all the activities in the wintering season, while resting, locomotion and feeding were dominant activities in the breeding season accounting for 86%. Throughout the year, resting peaked in the afternoon, while feeding reached its maximum at noon. As to the breeding ecology, ducks started laying eggs in early May and hatching in the middle of June. The mean clutch size was 9.41 ± 5.67 eggs, ranging between 1 and 11 eggs with a super clutch of 22 eggs giving the evidence of conspecific brood parasitism. Hatching success was low (55%) because of nest desertion, egg predation and egg infertility. The clutch size and hatching were positively correlated to the nest depth, the mean of which was 7.92 ± 4.94 cm.

Baltagalvė stačiauodegė *Oxyura leucocephala* yra viena iš labiausiai nykstančių ančių rūšių pasaulyje. Visame paplitimo areale šios rūšies ekologija, elgsena bei veisimosi biologija pastaraisiais dešimtmečiais susilaukė didelio mokslininkų dėmesio. Siekiant užpildyti žinių spragas apie *O. leucocephala* populiacijas Šiaurės Afrikoje, Tongos ežere (į Ramsaro sąrašą įtraukta saugoma vietovė, El Kala, Alžyras) buvo atlikti šių ančių paros ir sezoninio aktyvumo bei veisimosi ekologijos tyrimai. *O. leucocephala* Tongos ežere aptinkamos nuolatos, didžiausias jų skaičius buvo užregistruotas sausio mėnesį. Vidutiniškai per metus paukščiai poilsiui skyrė 62,41% paros laiko, judėjimui – 18,50%, mitybai – 11,04%, plunksnų švarinimui – 5,56%, skraidymui – 0,53%, agresyviai elgsenai – 0,13%, poravimosi ritualams – 1,83% paros laiko. Laiko paskirstymas įvairiai elgsenai žiemojimo bei veisimosi sezonuose reikšmingai skyrėsi. Žiemojimo metu poilsis ir judėjimas užėmė 89% paros laiko; veisimosi laikotarpiu dominavo poilsis, judėjimas ir mityba, sudarydami 86% paros laiko. Per metus antys daugiausia laiko skyrė poilsiui popietės metu ir mitybai vidurdienį. Nustatyta, kad antys pradeda dėti kiaušinius gegužės pradžioje, pirmieji jaunikliai išsiperi birželio viduryje. Vidutinis dėties dydis buvo 9,41 ± 5,67 (1–11) kiaušinių. Didžiausioje aptiktoje dėtyje rasti 22 kiaušiniai; tai rodo vidurūšinio lizdinio parazitizmo buvimą. Išsiperėjimo procentas buvo žemas (55%) dėl šių priežasčių: (1) kai kurios antys palikdavo lizdus; (2) grobuonys sunaikindavo kiaušinius; (3) kiaušiniai buvo neapvaisinti. Nustatyta teigiama dėties dydžio ir išsiperėjimo procento koreliacija su lizdo gyliu, kuris vidutiniškai siekė 7,92 ± 4,94 cm.

Keywords: breeding; daily activity budget; White-headed Duck; endangered; Algeria

Introduction

Increasing interest has been shown in the study of anatidae activity budget over the last decades in order to gain the understanding of this species' habitat use and interspecific niche partitioning, which help to conserve waterfowl communities in their natural habitats (Rave and Baldassare 1989). Studies on breeding ecology, on the other hand, investigate nest site selection and ecological parameters that are likely to influence breeding success. Since biotic and environmental parameters that govern the wintering season (especially food availability) have been shown to determine the survival and breeding success of individuals (Heitmeyer and Fredrickson 1981; Krappu 1981), studies on both activity budget and breeding ecology are important to the understanding of the population dynamics of anatidae (See Armengol et al. 2008; Atiénzar et al. 2012).

The White-headed Duck (*Oxyura leucocephala*) is a Palaearctic threatened species ranked as endangered in the IUCN red list. The global population size is estimated at less than 10,000 mature individuals distributed over a fragmented range extending from the Mediterranean to South-west Asia. Habitat degradation, environmental factors, climate change and hybridization with its congeneric Ruddy duck (*Oxyura jamaicensis*) are thought to be the most important threats affecting its

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numbers (Anstey 1989; Tucker and Heath 1994; Sanchez, Green, and Dolz 2000; Hughes et al. 2006).

In the Mediterranean basin, the species is currently native to Spain, Algeria and Tunisia. Over the last century, the Spanish population has undergone severe changes in size reaching 400 individuals in 1950 and decreasing to 22 individuals in 1977. The effective conservation plan including habitat protection, hunting restriction and captive breeding played a crucial role in the increase of the local population to 2500 individuals (Hughes 2006). However, recent estimations of Algerian and Tunisian populations have shown substantially smaller numbers with a total of 400–600 individuals for both countries combined. According to Heim De Balsac and Mayaud (1962), the species was abundant in Algeria in the middle of the nineteenth century, especially at Lake Fetzara near Bône province. Nowadays, the Algerian population is restricted to small colonies distributed in north-eastern wetlands (El Kala and Guerbes-Sanhadja complex) (Coulthard 2001; Metallaoui and Houhamdi 2008; Metallaoui et al. 2009; Metallaoui and Houhamdi 2010; Lazli, Boumezbeur, Moali-Grine, et al. 2011) and eastern high plains (Houhamdi et al. 2009; Baaziz et al. 2011).

Prior to this study, diurnal activity budget and breeding ecology of the species have rarely been investigated (Boumezbeur 1993; Green et al. 1993; Khan et al. 1996; Houhamdi et al. 2009; Metallaoui et al. 2009; Lazli, Boumezbeur, Moali-Grine, et al. 2011; Lazli, Boumezbeur, Pérennou, et al. 2011). In this paper, we focused on diurnal time-activity of the White-headed Duck in both wintering and breeding seasons as well as on its breeding ecology at Lake Tonga.

Study site

The study was conducted at Lake Tonga (36°53′N, 08°31′ E) situated in the extreme north-east of Algeria near the Algerian-Tunisian border (Figures 1 and 2). It covers an area of 2600 ha and flows into the Mediterranean Sea through an artificial canal. Almost 80% of its area is covered by helophytes (Lesser Bulrush *Typha angustifolia*, Common Club-rush *Scirpus lacustris* and Common Reed *Phragmites australis*) and hydrophytes (*Nymphaea alba* and *Potamogeton pectinatus*) (Aissaoui et al. 2011; Lazli, Boumezbeur, Moali-Grine, et al. 2011). This wetland was designated a Ramsar site in 1982. It represents the most important breeding site for the White-headed Duck in Algeria (Lazli, Boumezbeur, Pérennou, et al. 2011), holding numerous anatid species during the wintering season, namely the Mallard (*Anas platyrhynchos*), the Common Teal (*Anas crecca*), the Eurasian Wigeon (*Anas penelope*), the Northern Shoveler (*Anas clypeata*), the Ferruginous Duck (*Aythya nyroca*) and the Tufted Duck (*Aythya fuligula*) (Lazli, Boumezbeur, Moali-Grine, et al. 2011; Lazli, Boumezbeur, and Moali 2012).

Materials and methods

Abundance and behaviour

Individuals of the White-headed Duck were counted monthly from an observation tower situated in Southwest near Oued El Hout village from August 2011 to July 2012 with a telescope KONUS-SPOT 20 × 60. Counts of ducks were done at noon using two methods depending on the population size: (1) counting the number of duck individuals separately when it did not exceed 200 individuals and (2) estimating their numbers visually when they

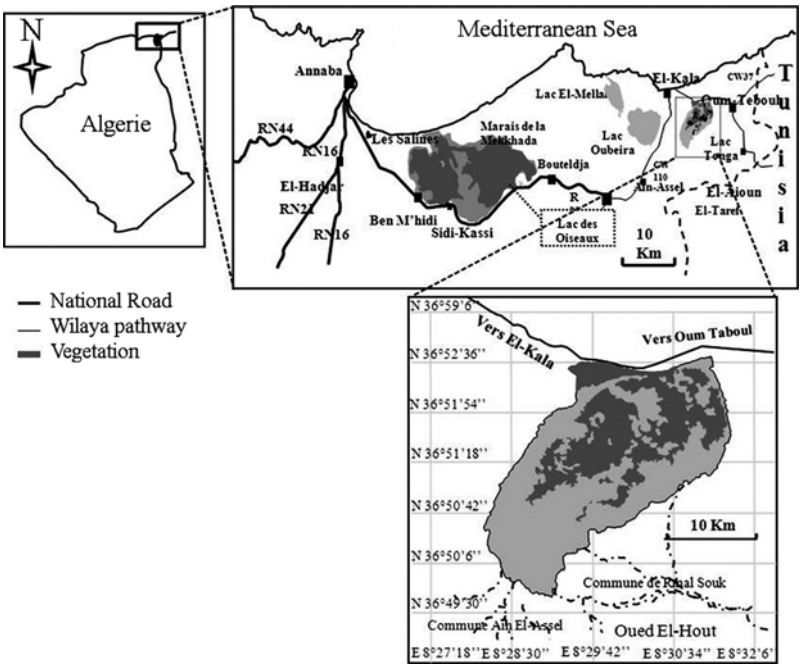

Figure 1. Location of Lake Tonga and spatial distribution of the White-headed Duck.

Figure 2. The southern part of Lake Tonga.

exceeded 200 individuals (Lamotte and Bourlière 1969; Blondel 1975). These counts were conducted in order to survey seasonal changes in the number of ducks and to determine the time when the number of individuals in the wetland reaches the peak.

Diurnal activity budget was investigated from August 2011 to July 2012. The species behaviour was divided into seven activities, namely feeding, resting, locomotion, preening, flying, courting and agonistic behaviour (see Tamisier and Dehorter 1999). We kept watch on its behaviour using instantaneous scan sampling at intervals of 60 min from 8:00 to 17:00 (Altmann 1974; Baldassare et al. 1988; Losito, Mirarchi, and Baldassare 1989; Tamisier and Dehorter 1999).

Nest measurements and morphometric parameters

From late April to early July, we visited the site fortnightly and measured a set of parameters related to nests and eggs within an area of 2 ha situated in the western part of the Lake. Internal and external diameters, nest depth, nest height above the water surface and water depth under the nest were measured with a decametre to the nearest cm. Egg length and width were measured with a digital calliper to the nearest 0.01 mm. Egg weight was measured with a Pesola balance to the nearest 0.1 g. Vegetation density around the nest was measured visually to the nearest 10%. Egg volume was measured using Harris's (1964) equation: $V = 0.476 \times \text{Length} \times \text{Width}^2/1000$. The clutch size was determined when the number of eggs did not change between two subsequent visits.

We used SPSS 17.0 to compute Spearman's rank correlation analysis. Non-parametric tests were used when data were not normally distributed. χ^2 tests were used to find out whether there is a significant difference in the activity budget between wintering and breeding seasons. Spearman correlations were carried out to test for a potential relationship between the clutch size, hatching success and six environmental variables (internal and external diameters, nest height, nest depth, vegetation density and water depth).

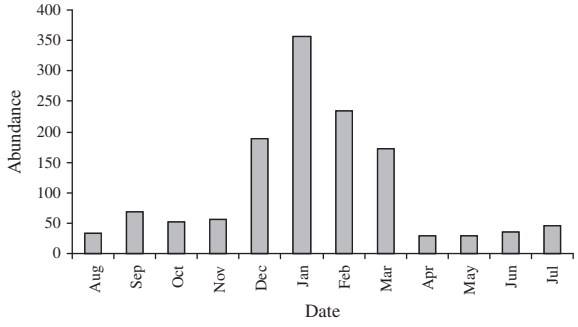

Figure 3. Monthly counts of the White-headed Duck at Lake Tonga (August 2011–July 2012).

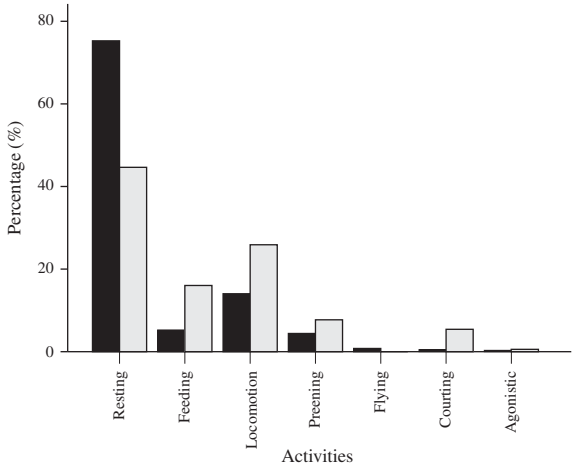

Figure 4. Diurnal activity rhythms of the White-headed Duck at Lake Tonga.

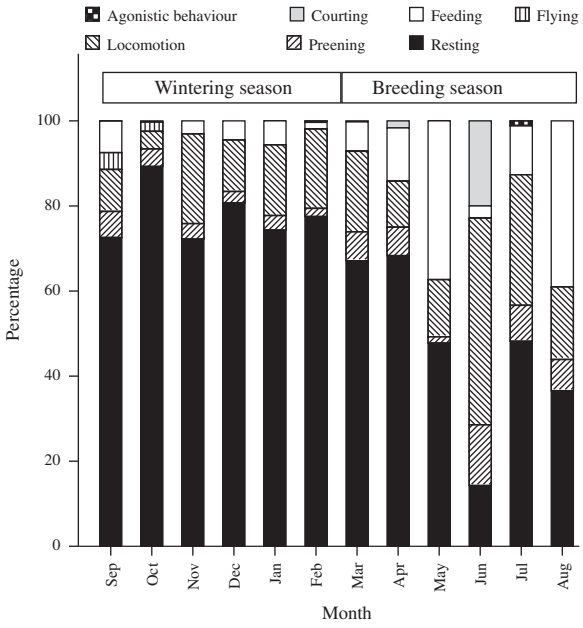

Figure 5. Monthly time-activity budget of the White-headed Duck at Lake Tonga.

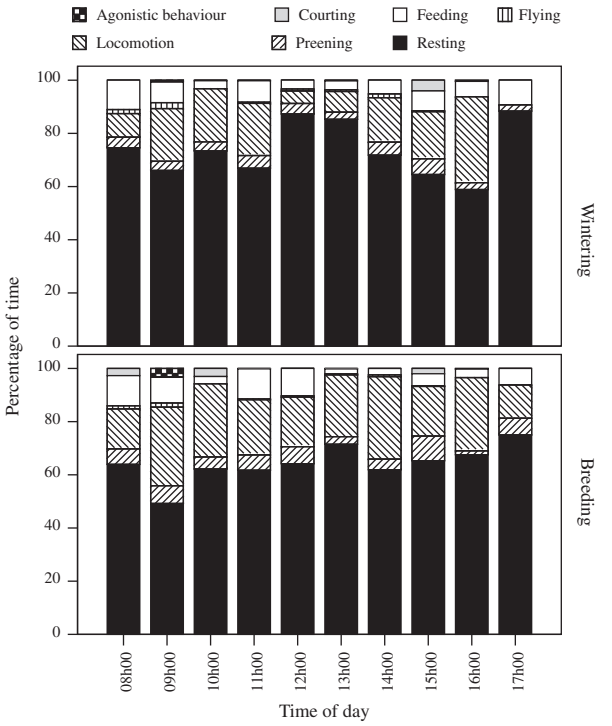

Figure 6. Time-activity budgets (per hour) of the White-headed Duck at Lake Tonga.

Results

Abundance

The White-headed Duck was present at Lake Tonga throughout the year. The number of individuals peaked in January reaching 356 ducks. Then the number gradually decreased until April slightly recovering by the end of the breeding season in July (Figure 3).

Diurnal activity budget

There were statistically significant differences recorded in the diurnal activity budget between wintering and breeding seasons (χ^2 test: $p < 0.05$ for all activities). During the wintering season, resting and locomotion were the dominant diurnal activities accounting for 89.29% of all the activities, while feeding constituted only 5.12% (Figure 4). In the breeding season, however, three activities dominated the diurnal behaviour, namely resting (44.46%), locomotion (25.89%) and feeding (16.02%) (Figure 4). Preening, flying and agonistic behaviour represented 5.22 and 8.01% of all the diurnal activities in wintering and breeding seasons, respectively (Figure 4). The comparison of the diurnal activity budget in the above-mentioned seasons revealed that there was a marked decrease in resting and flying and a substantial increase in locomotion, feeding, preening and agonistic behaviour in the breeding season compared to that of wintering (Figure 5).

The combined data on time-activity budget during wintering and breeding seasons were as follows: resting (62.41%), locomotion (18.50%) and feeding (11.03%), which constituted 91.94% of all the activities. Preening (5.56%) and courting (1.83%) were observed less frequently, while flying (0.52%) and agonistic behaviour (0.13%) was noted rarely (Figure 4).

Diurnal rhythms of the White-headed Duck (both seasons pooled) are presented in Figure 6. Resting did not change substantially during the day showing a peak in late afternoon. Feeding was the highest early and late in the morning. Preening and locomotion showed a similar trend with minimums late in the afternoon. Flying, courting and agonistic activities were mainly observed in the morning. However, diurnal rhythms of the three main activities varied significantly between wintering and breeding seasons (Figure 6). Resting showed similar diurnal proportions during the wintering season with a gentle peak at noon but it decreased in the morning in the breeding season. Feeding decreased in the afternoon during the breeding season. Locomotion did not show any important variations from one season to another.

Table 1. Characteristics of the White-headed Duck's nest at Lake Tonga. The total number of nests is 16.

	External diameter (cm)	Internal diameter (cm)	Nest depth (cm)	Water depth (cm)	Nest height (cm)
Mean	29.77	20.69	7.92	67.31	3.08
SD	3.90	4.05	4.94	40.50	4.35
Min	24	12	3	30	0
Max	35	25	19	130	10

Figure 7. The White-headed Duck's nest containing nine eggs.

Table 2. Measurements of the White-headed Duck's eggs at Lake Tonga. The total number of eggs is 64.

	Weight (g)	Length (mm)	Width (mm)	Volume (cm^3)
Mean	94.39	67.75	51.07	84.27
SD	8.24	2.35	1.82	70.32
Min	80	60.86	48.48	70.32
Max	110	76.76	61.81	128.2

Table 3. Spearman's rank correlation of six ecological parameters with the clutch size and hatching of the White-headed Duck at Lake Tonga.

		Clutch size	Hatching
Internal diameter	*r*	0.12	0.24
	p	0.68	0.41
External diameter	*r*	0.29	0.40
	p	0.33	0.17
Nest depth	*r*	0.74	0.86
	p	0.003	0.0001
Water depth	*r*	−0.27	−0.32
	p	0.37	0.27
Nest height	*r*	−0.03	0.04
	p	0.91	0.88
Vegetation density	*r*	0.03	0.08
	p	0.90	0.78

Breeding ecology

A total of 16 nests of the White-headed Duck were found and surveyed within the sampling area. Most nests were placed on tufts of *Scirpus maritimus* (7 nests, 44%), *S. lacustris* (5 nests, 31%) and a small proportion of nests were built on plant formations consisting of *Salix pedicellata* and *Typha angustifolia* (4 nests, 25%).

Table 1 presents characteristics of nests. The first egg was recorded in early May (5th), while the last one laid was noted in the middle of June (13th) showing a peak in late May. The mean clutch size was 9.41 ± 5.67 eggs ranging from one to 22 eggs (Figure 7). The first and the last hatching periods were recorded in the middle of June (13th) and in early July (4th), respectively, with a peak in late June. A total of 80 eggs were laid and 55% of them successfully hatched out. Hatching failure was caused by nest desertion (16.25% of eggs), nest predation (12.5% of eggs) and infertility (16.25% of eggs). The clutch size and hatching were significantly positively correlated to the nest depth but not related to all other variables (Table 2). Egg dimensions and weight are presented in Table 3.

Discussion

The White-headed Duck is known to have been resident in Algeria for a long time (Heim De Balsac and Mayaud 1962; Ledant et al. 1981). At Lake Tonga, its numbers have increased substantially over the past four decades, from 40 individuals in 1976 to 1045 in 2010 (Lazli, Boumezbeur, Moali-Grine, et al. 2011). This population growth is most likely due to the effective protection measures implemented at the site and a possible immigration of the nearby Lac des oiseaux population, which has suffered a significant degradation over the last decade (Isenmann and Moali 2000). During our study, we surveyed only the southern part of Lake Tonga, thus we recorded only a maximum of 356 individuals.

The abrupt increase in numbers in early winter is due to the arrival of the migrant population at Lake Tonga. At the end of the wintering season, the numbers decreased gradually because of the migrant population's departure. The origin and destination of migrant individuals are not yet known and require implementing a long-term banding scheme. Finally, the population slightly increased in numbers at the end of the breeding season because of the chicks born during that period.

Our results on the diurnal activity budget during the wintering season were similar to those presented by Green et al. (1993) at Lake Burdur (Turkey), where resting, feeding and locomotion were the dominant activities accounting for 93% of all the behaviour vs. 94.41% recorded in our study. During the above-mentioned study, Green et al. (1993) found substantial differences in the diurnal activity budget between different sites (within the same lake). However, the findings reported from one of them, named 'Sugar factory', were the closest to our results. However, Houhamdi et al. (2009) showed high levels of daytime feeding (10.77 ± 1.39%) and locomotion (38.89 ± 1.96%) in Algerian high plain wetlands characterized by semiarid conditions. This

could be explained by the low productivity of nocturnal foraging sites (in Chironomids) in that region providing low prey intake. As a result, ducks are forced to spend more time swimming and foraging during daytime to satisfy their nutritional needs as it was observed in other studies on the same species (Michot, Moser, and Norling 1994).

Species behaviour changes from wintering to breeding season because birds respond to different environmental (temperature and photoperiod) and biological demands (hormones) accordingly (Williams 2012). Both feeding and locomotion increased, while resting decreased substantially in the breeding season. It is most likely that foraging sites were extensively exploited during the wintering season. As a consequence, Chironomid availability decreased in the breeding season. Therefore, the White-headed Duck was forced to swim more to find suitable foraging sites and foraged longer during the day. Consequently, the birds rested less during that season. Preening, however, increased in the breeding season because birds probably took care of their feathers and removed ectoparasites, which are known to be common during that season (Clayton 1991; Cotgreave and Clayton 1994). Flying was not observed during the breeding season because individuals chose relatively sheltered habitats that prevent them from human disturbance and predation attempts by the Western Marsh-harrier (*Circus aeruginosus*), usually noted during the wintering season. Courtship and agonistic behaviour were two intimately related behaviour patterns displayed mainly during the breeding season, which is consistent with the species polygamous mating system and territorial behaviour during that period (Amat and Sanchez 1982; Torres-Esquivias 1982; Torres-Esquivias and Raya Gomez 1983; Torres-Esquivias et al. 1985). Also, males are known to change their peak colour in winter (about December) during which they start to intensify their courtship behaviour.

In this study, the diurnal feeding activity was mainly observed in the morning. Studies on the diurnal activity budget of the same species and other ducks showed that feeding peaked early in the morning and late in the afternoon (Paulus 1988; Green et al. 1993; Michot, Moser, and Norling 1994). In the same way, locomotion showed its maximum in the morning because the species usually swam when it foraged. However, resting peaked early in the afternoon probably because temperatures at the water surface were relatively higher providing advantages in terms of thermoregulation (Green et al. 1993). Preening did not show a marked peak but it decreased early and late in the afternoon when individuals devoted more time to resting. Courtship and agonistic behaviour were mainly recorded in the morning as it was observed in the case of the Ferruginous duck at the same site (Aissaoui, Houhamdi, and Samraoui 2009).

Lazli, Boumezbeur, Moali-Grine et al. (2011) stated that the Algerian population is the earliest breeding one compared to other colonies studied so far. Our survey on the breeding parameters of the White-headed Duck suggested that the species started to build nests at Lake Tonga early in April. The first egg was recorded in early May, which is similar to the egg laying period reported by Boumezbeur (1993), and one week later than that reported by Lazli, Boumezbeur, Pérennou, et al. (2011) at the same study site. These variations in egg laying date probably depended on temperature (Visser, Holleman, and Caro 2009). However, the egg laying period observed during this study was three weeks shorter than that reported by Boumezbeur (1993) and Lazli, Boumezbeur, Pérennou et al. (2011), which is probably due to the small sample size of the nests surveyed. In Spain, egg laying takes place between May and early July (Amat and Sanchez 1982; Hughes and Green 2005).

In addition, egg hatching started in the middle of June, three weeks later than reported by Lazli, Boumezbeur, Pérennou, et al. (2011). This large gap is probably due to the fact that the first eggs laid at Lake Tonga were deserted or predated. The hatching period of the Spanish population lasts approximately six months, from April to September with a peak in May (Amat and Sanchez 1982; Torres-Esquivias and Moreno-Arroyo 2000; Torres-Esquivias 2003; Torres-Esquivias 2004; Green 2006), whereas the Algerian population starts hatching in May and ends in August with a maximum in June and July (Boumezbeur 1993; Lazli, Boumezbeur, Pérennou et al. 2011).

The species is known to lay 4–9 eggs with a modal clutch size of 5–6 eggs (Carbonell 1983; Gordienko, Drobotsev, and Koshelyev 1986). During this study, we recorded a larger mean clutch size of 9.41 $\pm$ 5.67 eggs and we noted four unusual clutches of 10, 10, 11 and 22 eggs. This revealed the occurrence of conspecific brood parasitism by one or two females as it was observed in its congeneric species *Oxyura jamaicensis* (Reichart 2008). The eggs measured during this study were smaller than those recorded in Garaet Timerganine, Garaet Ouled M'barek, Garaet Ouled Amara, and Chott Tinsilt situated in Algerian high plains, 180 km south-west from Lake Tonga (Houhamdi et al. 2009). The current study sites are characterized by sub-humid climate with high productivity. However, the latter wetlands are located in semiarid areas with lower food availability, and this could be the reason for clutch size variation among populations (Clifford and Anderson 2001).

Hatching success (55%) was similar to that reported by Boumezbeur (1993) at the same site (55.7%) but lower than that of Turkish populations (78.94%) (Nergiz, Tabur, and Ayvaz 2011). Potential predators were probably Black Rats (*Rattus rattus*) and the Viperine Snake (*Natrix maura*). We found a significant positive correlation of the clutch size and hatching success with the nest depth, i.e. the deepest nests supported larger clutches and ensured higher survival of eggs. According to our observations, eggs deposited in the deepest nests were

usually covered with a layer of twigs and feathers so that predators could not detect them. We suggested that the deepest nests were built by experienced breeding pairs, which were able to protect their broods from predators using this antipredation behaviour.

In conclusion, this study provides important data on the activity budget and breeding ecology of the White-headed Duck at the most important site for the species in North Africa. Further studies should investigate the nocturnal behaviour as well as spatiotemporal distribution of the population according to food (Chironomids) availability at Lake Tonga. Although the local status of the species is currently promising, conservation measures should be reinforced to reduce hunting, habitat degradation and human disturbance.

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