ABUNDANCE AND DIURNAL TIME ACTIVITY BUDGET OF THE THREATENED SPECIES WHITE-HEADED DUCKS (ANATIDAE: *Oxyura leucocephala*) IN AN UNPROTECTED AREA, BOUSSEDRA MARSH, NORTHEAST ALGERIA

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Abstract

Amine H.M., Rabah Z., Zinette B., Abdeldjalil Y., Mouslim B., Sadek A., Mohammed D., Menouar S., Moussa H.: Abundance and diurnal time activity budget of the threatened species white-headed ducks (Anatidae: *Oxyura leucocephala*) in an unprotected area, Boussedra marsh, Northeast Algeria. *Ekológia (Bratislava)*, Vol. 40, No. 4, p. 384–391, 2021.

The white-headed duck is a globally threatened species and its populations have become fragmented and undergone major decline in recent decades. Changes including long-term abundance (five times from 2005 to 2018) and diurnal activity budget (2010–2011 and 2017–2018) with respect to the effect of habitat features at Boussedra marsh (unprotected area) were compiled in order to fill some gaps in the status and trend of North African populations. The population size of the white-headed duck decreased over years from 2010 to 2018 by about 52.81%, and was positively associated with interior vegetation area, but not significantly with water surface area. Trends of population dynamics differed among seasons, and the number was higher in wintering than breeding season. Sleeping (44.93%, 23.74%) and feeding (59.09%, 27.43%) were the dominant diurnal activities at both the years of study, respectively. Boussedra marsh plays an important ecological role as a diurnal forging habitat and reproduction site for this threatened species and as a shelter for other waterfowl.

Key words: *Oxyura leucocephala*, abundance, diurnal activity budget, Boussedra marsh, Northeast Algeria.

Introduction

Habitat loss and degradation are the most important pressures contributing to the worldwide decline of biodiversity (Vié et al., 2009; Balmford, Bond, 2005), mainly due to anthropogenic activities such as pollution, invasive species, agricultural activities (Kingsford et al., 2016), urban development (Foley et al., 2005) and climate change (Woodward et al., 2010). Wetland ecosystems are a natural resource of global significance in terms of productivity, which support rich biodiversity and provide roosting, nesting and feeding habitat for many waterbirds, insects and plants during their life stages (Bobbink et al., 2006; Bunn, Arthington, 2002). Waterbirds represent one of the most obvious indicators of the health and diversity of such ecosystems, and these cumulative impacts undermine the capacity of wetlands to continue to support this diversity of waterfowl communities.

Increasing interest has been shown in the study of waterbirds over the last decades and it showed that many waterbird populations are declining, with 17% considered globally threatened (BirdLife International, 2017). More specifically, trend estimates for waterbirds from the family Anatidae (ducks, geese and swans), of which trend data is available for 92% of these species, show that 80 out of 152 of these species (53%) are decreasing (BirdLife International, 2017). According to the ecological conditions in wintering, passage and breeding grounds, waterbirds adapt their behaviours and phenologies, which are dependent on climatic conditions, availability of trophic resources, water depth and anthropogenic pressures (Tamsier, Dehorter, 1999; Baldassarre, Bolen, 1994). The importance of habitat variation and factors such as vegetation structure, topography and disturbance regimes strongly affect the use of wetlands by waterbirds (Pearman, 2002; Polis et al., 2004). The understanding of biotic and abiotic

factors affecting species distribution, phenology, abundance and behaviour with respect to geographical locations and species is crucial in ecology and conservation (Stephens et al., 2016; Thackeray et al., 2016; Guisan et al., 2017).

The white-headed duck *Oxyura leucocephala* is a globally threatened species currently classified as endangered in the International Union for Conservation of Nature red list. It occupies different habitats of wetlands, for example, freshwater, brackish to saline wetlands, permanent or temporary, and from wet to arid areas (Cramp, Simmons, 1977; Anstey, 1989; Atoussi et al., 2017). The distribution of white-headed duck is fragmented, with small resident populations extending from the Mediterranean to Southwest Asia (Green, Anstey, 1992). Several factors threaten its number, including habitat degradation, pollution, agriculture, climate change, hybridisation and competition with its congeneric species ruddy duck (*O. jamaicensis*) (Hughes, 1991, 2006; Rose, 1993; Torres et al., 1994).

In Algeria, the species was abundant in the middle of the 19th century (Heim De Balzac, Mayaud, 1962). Nowadays, most of the studies on white-headed duck population are conducted at protected areas in the coastal wetlands of Northeast Algeria (El Kala and Guerbes-Senhadja complex) and some of the eastern high plains (Coulthard, 2001; Houhamdi et al., 2009; Baaziz et al., 2011; Chettibi et al., 2013). Nothing was known about the status and behaviour of the species at this unprotected marsh prior to the current study, and also, a huge gap is noted regarding studies of long-term population trends and the effect of habitat features on the abundance and behavioural activities of this wintering and breeding waterbird. Yet, Boussedra marsh is an ideal refuge area for wintering and breeding of many species of waterbirds (Boudraa et al., 2014); it is suffering major environmental change as a result of disturbing activities by humans, and drastic decline has occurred recently in the numbers of white-headed ducks and other waterbirds such as ferruginous duck (*Aythya nyroca*) and marbled duck (*Marmaronetta angustirostris*) (Atoussi et al., 2013).

In this paper, we aimed to quantify the long-term white-headed duck abundance and diurnal time activity in both wintering and breeding seasons in an unprotected wetland of Northeast Algeria, as well as to interpret the patterns observed in relation to certain variations in some characteristics of habitat features of this wetland undergoing steady degradation.

Material and methods

Study site

Our study was conducted in Boussedra (36°50'40.88"N, 7°43'37.30"E), a lentic unprotected, freshwater marsh of Northeast Algeria, in an area of 55 ha, losing more than 50% of its former area up to 2010, which is embedded in an urban landscape with surrounding houses. It is known for its high productivity and diversity of waterbirds, and harbours large wintering and breeding populations of waterbirds including the rare white-headed duck (*Oxyura leucocephala*) and ferruginous duck (*Aythya nyroca*) (Boudraa et al., 2014). The vegetation of Boussedra is dominated by *Phragmites australis*, *Scirpus maritimus* and *S. triqueter*. The climate is typically Mediterranean with a short wet period between October and

February and a long dry season between March and September. In the region, temperatures typically do not drop below 0 °C, with the annual average being 17.7 °C (14.7–20.7 °C), and rainfall is higher than in most other North African areas, recording 1300 mm per year.

Sampling procedure

In 2005–2018, we visited the site five times (2005, 2010, 2011, 2017 and 2018). Each year, the number of individuals was counted biweekly each month during the wintering and breeding seasons from September to March using a telescope *Konus* 20 × 60 at a distance of 150–200 m during the morning and early afternoon (10:00–16:00 hours), when the species is actively foraging. The species feeds in relatively small flocks with a low degree of clustering, which makes it easy to count. We took the maximum number of individuals in each count.

Habitat features

Area covered by emerging vegetation in the interior of the pond and water surface area were estimated through high-quality satellite images of the pond (Google Earth), and these habitat features were calculated using free open source software QGIS (QGIS Development Team, 2021), only once for the entire sampling period each year.

Diurnal activity budget

Diurnal activity budgets of white-headed duck were studied from fixed observation points, twice a month each year, during the period September–March, with continuous observations from 08:00 to 16:00 hours using a telescope (25 × 60). Thus, the study encompassed 28 surveys and totalled 224 h of monitoring for the two wintering and breeding seasons of 2010–2011 and 2017–2018. White-headed duck's activities were surveyed using the scan method (Altmann, 1974), which consists of observing and recording the instant activities of the individuals for 15 min by dividing their behaviour into seven activities: feeding, sleeping, swimming, preening, flying, courtship and antagonistic behaviours. We took the total number of individuals of the day for each observed behaviour.

Statistical analysis

We carried out our statistical analysis with R 3.5.4 software (R Development Core Team, 2019). First, we checked the normality, homogeneity assumptions, independence and residual patterns in the data (Zuur et al., 2007). Multiple linear regression was used to look for the change in abundance across season and years, using season and years as explanatory variables and abundance as the response variable. The effects of habitat features on the variation of white-head ducks' population size were analysed using linear regression.

To identify how time budget of each behavioural activity varies at multiple time scales, that is, 'year', 'season', a multiple linear regression was applied with one-level interactions in each single linear model. Non-significant interaction was discarded from the model. Values are presented as mean ± SD.

Table 1. Multiple linear regression summarize testing the effects of year, season on the variation of White headed duck's population size, and Habitat features (Interior vegetation, and water area surface) at Bousseadra marsh (North-Eastern Algeria).

	Estimate	Std. Error	t value	P Value
Log(Abundance)				
intercept	74.78	21.35821	3.502	0.000906 **
Year	-0.03	0.01061	-3.319	0.001576 **
Season wintering	0.25	0.10172	2.549	0.013522 *
Interior vegetation				
intercept	2.180e+02	5.180e+01	4.208	9.24e-05 ***
Year	-1.077e-01	2.574e-02	-4.185	9.97e-05 ***
Season wintering	-8.625e-15	2.467e-01	0.00	1
Water surface area				
intercept	-3.378e+03	4.203e+02	-8.037	5.96e-11 ***
Year	1.694e+00	2.089e-01	8.108	4.56e-11 ***
Season wintering	1.333e-13	2.002e+00	0.00	1

Table 2. Linear regression testing the effect of habitat features on the variation of White headed duck's population size at Bousseadra marsh (North-Eastern Algeria).

Log (Abundance)	Estimate	Std. Error	t value	P Value
intercept	3.83044	0.07926	48.33	< 2e-16 ***
Interior vegetation	0.15972	0.04991	3.20	0.00223 **
intercept	4.184640	0.162750	25.712	<2e-16 ***
Water surface area	-0.005607	0.005146	-1.089	0.28

Fig. 1. Change of abundance of the White-headed Duck during 2015-2018 in Bousseadra marsh (north-eastern Algeria).

Results

Population dynamics

Through all the years of study, the peak was recorded in February and March and population collapsed slowly until August. The maximum

number of white-headed ducks was observed in 2005 with 142 individuals and the minimum number in 2018 with a decrease of 52.81% (75 individuals max.). The white-headed duck numbers decreased significantly across years at Bousseadra marsh ($p = 0.001$), and the population size varied significantly among seasons and it was higher in wintering than breeding season ($p = 0.013$; see Table 1, Fig. 1).

Fig. 2. Effect of vegetation surface area (A), and water surface area (B) on the variation of population size of the White-headed Duck in Bousedra marsh (north-eastern Algeria).

Temporal pattern of habitat features

The interior vegetation area decreased significantly across years (a decrease of 56.66%) ($p < 0.0001$), but not among seasons. On the other hand, water surface area increased significantly across years (45.42% increase) ($p < 0.0001$), but not among seasons (see Table 1).

Relationship between habitat features and population dynamics

The number of white-headed ducks was positively associated with interior vegetation area and negatively but not significantly associated with water surface area ($p = 0.002$ and $p = 0.28$, respectively; see Table 2, Fig. 2).

Temporal pattern of diurnal activity budget

Throughout the wintering and breeding seasons, the rhythms of diurnal activities of white-headed ducks were monitored during 224 h of the study in 2010–2011 and 2017–2018 at Bousedra marsh. The combined data on time activity budget during wintering and breeding seasons were as follows. Sleeping (44.93, 23.74%) and feeding (59.09, 27.43%) were the dominant diurnal activities, followed by swimming (16.27, 2.71%) and preening (9.41, 6.85%) in 2010–2011 and 2017–2018, respectively (see

Fig. 3). Flying (0.92, 2.31%) and courtship (3.17, 0.95%) were observed less frequently, while antagonistic behaviour (1.53, 0.63%) was noted rarely in 2010–2011 and 2017–2018, respectively.

The annual analysis of patterns of diurnal activities showed that sleeping, feeding and flying were increased significantly between years ($p = 0.0324$, $p = 0.0150$, $p = 0.0004$) with an increase of 14.16, 3.69 and 1.39%, respectively, and the species fed more (13.38%) in wintering than during the breeding season ($p = 0.0001$). Although swimming and courtship activities were significantly decreased between years ($p < 0.0000$, $p = 0.0495$) with a decrease of 13.56 and 2.22%, respectively. Among seasons, swimming behaviour changed significantly ($p = 0.0481$, $p = 0.0024$) with an increase of 3.14% in 2010–2011, and a decrease of 1.69% in 2017–2018. In courtship, we detected significant change from wintering to breeding season for both years with an increase of 3.39 and 1.49%, respectively. The other activities, preening and antagonistic behaviour, were not different between years and among seasons ($p = 0.544$, $p = 0.19091$; see Table 3, Fig. 4).

Discussion

The study presents a recent historical account of the abundance and time activity budget of the white-headed duck at Bousedra marsh in relation to variations in some habitat features of this local degraded wetland. Our results suggest that the population size collapses across years and with changes in behavioural activities by some abiotic factors (discussed below). These data might

Fig. 3. Annual diurnal activity rhythms during 2010\2011 and 2017\2018 of the White-headed Duck at Boussedra marsh (north-eastern Algeria).

Fig. 4. Seasonal time-activity budget during 2010\2011 and 2017\2018 of the White-headed Duck at Boussedra marsh (north-eastern Algeria).

Table 3. Multiple linear regression testing the effects of years and season on the variation of diurnal activities of the White headed duck at Bousseadra marsh (North-Eastern Algeria).

	Estimate	Std. Error	t value	P Value
Sleeping				
intercept	45.46	13.46	3.377	0.0024 **
Year 2018	21.57	9.52	2.266	0.0324 *
Season wintering	-16.46	13.60	-1.210	0.2376
Feeding				
intercept	33.500	4.331	7.734	4.32e-08 ***
Year 2018	8.000	3.063	2.612	0.015005 *
Season wintering	-19.750	4.376	-4.513	0.000132 ***
Swimming				
intercept	14.214	1.588	8.953	2.84e-09 ***
Year 2018	-8.929	1.123	-7.953	2.61e-08 ***
Season wintering	-3.333	1.604	-2.078	0.0481 *
Preening				
intercept	7.7143	0.9859	7.825	3.51e-08 ***
Year 2018	-0.4286	0.6971	-0.615	0.544
Season wintering	-1.3333	0.9961	-1.339	0.193
Courtship				
intercept	4.9286	0.9301	5.299	1.72e-05 ***
Year 2018	-1.3571	0.6577	-2.064	0.04958 *
Season wintering	-3.1667	0.9397	-3.370	0.00244 **
Antagonistic				
intercept	1.7500	0.5260	3.327	0.00272 **
Year 2018	-0.50	0.3719	-1.344	0.19091
Season wintering	-0.7917	0.5314	-1.490	0.14882
Flying				
intercept	0.2857	0.4962	0.576	0.569929
Year 2018	1.4286	0.3509	4.071	0.000413 ***
Season wintering	0.4167	0.5014	0.831	0.413825

shed light on the future trend of this threatened species in the context of conservation-oriented strategies for waterbirds.

In the last century, the white-headed duck was known to be a resident of Algeria (Ledant et al., 1981). In the northeast of Algeria, El Kala wetland complex with (lac Tonga, lac des Oiseaux, lac Oubeira), lac Fetzara (Annaba region), and lac Holloula (Algiers region), were the main areas for this species (Heim de Balzac, Mayaud, 1962; Van Dijk, Ledant, 1983). The number showed some fluctuations over years; it increased substantially over the past four decades from 40 individuals in 1976 to 1045 in 2010 at lac Tonga (Lazli et al., 2011). Recent studies have shown that the maximum number of species at the same site was 356 individuals in 2011–2012 (Chettibi et al., 2013); also, at Bousseadra marsh (Annaba region), the maximum number was >250 in 2011 (Meziane et al., 2014), which decreased to 54 birds in 2013 (Boudraa et al., 2014) at the same site. Unfortunately, 50% of suitable, natural wetlands have been severely degraded since 1900 in North Africa (Hollis, 1992), and many waterbirds suffered under several pressures such as anthropogenic activities, pollution, climate change and poaching (Kingsford et al., 2016; Atoussi et al., 2013). However, it is likely that due to irregular surveys and lack of long-term surveys in all wintering and breeding sites of the

species, the overall number of white-headed ducks in northeastern Algeria has been underestimated.

In our study, we surveyed the number of white-headed ducks at Bousseadra marsh from 2005 to 2018 (five times); we recorded only a maximum of 142 individuals in 2005 and the number decreased substantially over the years of study (by 50% in 2018). This decrease may be associated with habitat degradation, as several studies have illustrated a range of threats that could be disturbing the species, such as industry, agricultural pollution and water extraction from the catchment (Green et al., 1993).

In addition, our results showed that the number was highly associated with decrease of vegetation, as the vegetation also was decreased over years, but not with the water surface. Moreover, several studies showed that the species is sensitive to some habitat requirements such as vegetation, which plays an important role during the breeding season when nesting occurs in dense vegetation, and sources of food because its diet is composed of a variety of invertebrates as well as seeds and some vegetative parts of plants (Torres et al., 1986; Anstey, 1989; Matamala et al., 1994). Anatidae occupy wetlands differently depending on habitat characteristics; for example, they search for sites that offer more food with high quality, and may be, this decline in numbers

across years is associated with degraded habitats and reduced food resources available at Boussedra marsh, such as vegetation, because ducks are heavily reliant on the seeds of aquatic plants (Meininger, Snoek, 1992; Green, Sánchez, 2003; Mouronval et al., 2007), and invertebrates (Green et al., 1999).

Our results on diurnal activity budget of the white-headed duck's behaviour showed that the two dominant diurnal activities of this species were sleeping and feeding. Our findings are similar with those of other studies on the white-headed duck (Oudihat et al., 2017; Atoussi et al., 2017), which indicates that feeding is among the dominant diurnal activities. The latter observations and our findings are in contrast with those of Chettibi et al. (2013) on Lake Tonga, who recorded that yearly diurnal activity was dominated by resting (62.41%) and locomotion (18.50%), as well as Metallaoui et al. (2009) on Garaet Hadj-Tahar, who found that resting and swimming were the dominant activities (39 and 36%, respectively), and Green et al. (1999) on Burdur Lake, who reported that resting was the dominant activity and the white-headed ducks spent much more time feeding at night (92%) than during the day (28%). The differences in habitat and site between these studies may explain these contrasting findings.

Indeed, the different responses of birds to meet their ecological needs, mainly nutritional requirements, may correlate with habitat structure (Cherkaoui et al., 2017) and other factors such as food, age and climate (Afton, 1979; Green et al., 1999; Bezzalla et al., 2019). The differences in time length and timing of the foraging behaviour may be due to the differences in water depth and trophic resources and the interaction between them. Starting from this point, during the study year on the behaviour of the white-headed duck, the water surface in 2011 was greater than in 2018 and was associated with an increase in vegetation surface. Such interaction may influence the supply of food than the behaviour (Amat, 1984).

These findings bring new insights concerning the trend of this population of white-headed ducks with a concern on the collapse of this species at a local scale in Northeast Algeria. Still, we think that it would be better to widen and improve our estimates of the population size of this species and other waterfowl on all wetlands of this eco-complex in order to determine the actual status in relation to natural habitat characteristics, and it is an essential step towards better management and conservation of biodiversity.

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