

Ecology, phenology and wintering behavior of Anatidae in the wetlands of Souk–Ahras (north–eastern Algeria)

N. Bouali, A. Baaloudj, M. Touarfia, I. Houhamdi, M. C. Maazi, M. Houhamdi

Bouali, N., Baaloudj, A., Touarfia, M., Houhamdi, I., Maazi, M. C., Houhamdi, M., 2021. Ecology, phenology and wintering behavior of Anatidae in the wetlands of Souk–Ahras (north–eastern Algeria). *Arxius de Miscel·lània Zoològica*, 19: 135–149, Doi: <https://doi.org/10.32800/amz.2021.19.0135>

Abstract

Ecology, phenology and wintering behavior of Anatidae in the wetlands of Souk–Ahras (north–eastern Algeria). Understanding the spatial and temporal niche of waterfowl is essential for effective management and conservation. To determine the ecology and phenology of Anatidae in North Africa, we carried out a 12–month study (2019–2020) in three wetlands that constitute a winter refuge for waterbirds in the Souk–Ahras region in north–east Algeria. We surveyed species richness, the seasonal pattern of the number of Anatidae, and their wintering diurnal behavior using regular counts and scans. We recorded thirteen species: six wintering species (*Anas clypeata*, *Anas penelope*, *Anas strepera*, *Tadorna tadorna*, *Aythya ferina*, *Anas crecca crecca*) and three sedentary nesting species (*Anas platyrhynchos*, *Oxyura leucocephala*, and *Aythya nyroca*), the latter two having national and international protection status. The survey showed that the wintering behavior of all these species is dominated by sleep, which on average accounts for almost half of the total time (48.91 %). Our results indicate that the three wetlands host a complex waterfowl community that includes species of conservation concern and that these sites likely play an essential role in providing the essential resources for wintering.

Dataset published through [GBIF](https://doi.org/10.15470/fozdot) (Doi: [10.15470/fozdot](https://doi.org/10.15470/fozdot))

Key words: Waterfowl, Wetlands, North Africa, Winter refuge, Specific richness, Phenology

Resumen

Ecología, fenología y comportamiento de Anatidae durante la invernada en los humedales de Souk–Ahras (noreste de Argelia). Comprender el nicho espacial y temporal de las aves acuáticas es esencial para una eficaz gestión y conservación de las mismas. Para determinar la ecología y fenología de Anatidae en el norte de África realizamos un estudio durante todo un año (2019–2020) en tres humedales de la región de Souk–Ahras (noreste de Argelia) que constituyen un refugio invernal para muchas aves acuáticas. Estudiamos la riqueza específica, el patrón estacional del número de Anatidae así como su comportamiento diurno durante la invernada mediante recuentos periódicos y escaneos. Registramos

trece especies, incluyendo seis especies invernantes (*Anas clypeata*, *Anas penelope*, *Anas strepera*, *Tadorna tadorna*, *Aythya ferina* y *Anas crecca crecca*) y tres especies nidificantes sedentarias (*Anas platyrhynchos*, *Oxyura leucocephala* y *Aythya nyroca*), las dos últimas de las cuales tienen estatus de protección nacional e internacional. El estudio mostró que el comportamiento de todas las especies durante la invernada está regido por el sueño, que de promedio representa casi la mitad del tiempo total (48,91%). Nuestros resultados indican que los tres emplazamientos albergan una compleja comunidad de aves acuáticas (entre las que se cuentan especies cuya conservación es motivo de preocupación) y que probablemente desempeñan un papel determinante en la oferta de recursos esenciales para la invernada.

Datos publicados en [GBIF](#) (Doi: [10.15470/fozdot](#))

Palabras clave: Aves acuáticas, Humedales, Norte de África, Refugio invernal, Riqueza específica, Fenología

Resum

Ecologia, fenologia i comportament d'Anatidae durant la hivernada als aiguamolls de Souk-Ahras (nord-est d'Algèria). Entendre el nínxol espacial i temporal dels ocells aquàtics és essencial per a una gestió i una conservació eficaces. Per determinar l'ecologia i la fenologia d'Anatidae al nord d'Àfrica vam portar a terme un estudi durant tot un any (2019–2020) en tres aiguamolls de la regió de Souk-Ahras (nord-est d'Algèria) que constitueixen un refugi hivernal per a molts ocells aquàtics. Vam estudiar la riquesa específica, el patró estacional del nombre d'Anatidae i també el comportament diürn dels ocells durant la hivernada mitjançant recomptes periòdics i escanejos. Vam registrar tretze espècies, incloent-hi sis espècies hivernants (*Anas clypeata*, *Anas penelope*, *Anas strepera*, *Tadorna tadorna*, *Aythya ferina* i *Anas crecca crecca*) i tres espècies nidificants sedentàries (*Anas platyrhynchos*, *Oxyura leucocephala* i *Aythya nyroca*), les dues últimes de les quals tenen estatus de protecció nacional i internacional. L'estudi va mostrar que el comportament de totes les espècies durant la hivernada està regit pel son, que de mitjana representa gairebé la meitat del temps total (48,91%). Els nostres resultats indiquen que els tres emplaçaments acullen una comunitat d'ocells aquàtics complexa (que inclou espècies la conservació de les quals és motiu de preocupació) i que probablement tenen un paper determinant en l'oferta de recursos essencials per a la hivernada.

Dades publicades a [GBIF](#) (Doi: [10.15470/fozdot](#))

Paraules clau: Ocells aquàtics, Aiguamolls, Nord d'Àfrica, Refugi hivernal, Riquesa específica, Fenologia

Received: 21/04/2021; Conditional acceptance: 28/05/2021; Final acceptance: 09/06/2021

Nouredine Bouali, Department of Biology, Faculty of Natural and Life Sciences, University of Souk-Ahras. P. O. 1553, Annaba Road, Souk-Ahras, Algeria and Department of Cellular and Molecular Biology, Faculty of Natural Science and Life, University Echahid Hamma Lakh-dar Eloued, El Oued 39000, Algeria.– Affef Baaloudj, Ines Houhamdi, Moussa Houhamdi, Laboratoire Biologie, Eau et Environnement, Faculty SNV-STU, University 8 May, 1945 Guelma, P. B. 401, 24000 Guelma, Algeria.– Moundji Touarfia, Mohamed-Chérif Maazi, LEAT Laboratory, Department of Biology, Faculty of Natural and Life Sciences, University of Souk-Ahras, P. O. 1553, Annaba Road, Souk-Ahras, Algeria.

Corresponding author: Affef Baaloudj. E-mail: baaloudj.affef@univ-guelma.dz

Introduction

The wetlands of north–eastern Algeria are characterized by great biodiversity of fauna and flora (Samraoui and De Belair, 1998; Samraoui and Samraoui, 2008; Khelifa et al., 2016). One of the key taxonomic groups that characterizes their ecological importance is waterbirds, not only because of their crucial role in ecosystem functioning (Temple and Wiens, 1989; Carignan and Villard, 2002) but also because they reflect the environmental health of these areas (Maazi, 2005; Houhamdi et al., 2009). Additionally, Algeria has a strategic geographic position in the Western Palaearctic, and it has more than 1,200 wetlands, 52 of which are internationally classified (Samraoui and Samraoui, 2008). These geographic and environmental attributes make local wetlands a high–quality refuge for waterbirds.

Algerian waterbirds have attracted a lot of attention over the last two decades, highlighting their great importance for biological conservation (Houhamdi et al., 2008; Saheb, 2009; Khelifa, 2012; Chettibi et al., 2013; Bara et al., 2014). These studies have focused on a wide range of waterbirds, including the common scaup (*Aythya nyroca*), the flamingo (*Phoenicopterus roseus*), the elegant avocet (*Recurvirostra avosetta*), white stilt (*Himantopus himantopus*), white–headed duck (*Oxyura leucocephala*), common cranes (*Grus grus*), teal (*Anas crecca crecca*), shelduck (*Tadorna tadorna*), Eurasian coot (*Fulica atra*) and souchet duck (*Anas clypeata*) (Boulkhssaim et al., 2006; Baaziz and Samraoui, 2008; Houhamdi et al., 2008; Mayache et al., 2005; Aissaoui et al., 2009; Metallaoui et al., 2009; Saheb et al., 2009; Maazi et al., 2010; Metallaoui et al., 2014). Among these birds, the Anatidae constitute the most dominant group in view of both species richness and abundance (Metallaoui and Houhamdi, 2008; Maazi, 2009; Houhamdi et al., 2009; Boukrouma et al., 2011; Baaziz et al., 2011; Merzoug et al., 2014; Guergueb et al., 2014; Amor Abda et al., 2015; Halassi et al., 2016; Atoussi et al., 2017). Given that the most threatened waterbirds also belong to Anatidae, studies on their ecology, behavior, and demography should be regularly conducted to build up a long–term database and support their management and conservation.

Our aim was to assess the abundance, species composition, and wintering diurnal behavior of Anatidae in three wetlands in the Souk–Ahras region in north east Algeria. The study was conducted from September 2019 to August 2020, thus covering both the wintering season and the breeding season. We determined species composition and abundance by means of bi–monthly visits, allowing us to monitor seasonal patterns. The wintering behavior was categorized into seven different behaviors. The time allocated to each behavior was then calculated using the scan method.

Material and methods

Study area

The wilaya of Souk–Ahras (4,365.59 km²) is located in north–eastern Algeria, at the limit of the Tunisian border on a strip of 88 km. It is bound to the northeast by the wilaya of El–Taref, Guelma in the northwest, Oum El–Bouaghi in the southwest, Tébessa in the south, and Tunisia in the east (fig. 1). The region has a Mediterranean climate; it is subhumid in the north and semi–arid in the south with cold winters and scorching summers in the south. Most wetlands in the region depend on the climatic conditions for their water supply, mainly rainfall. Our work covered three natural wetlands: Tiffetch and El–Kaf hill reservoirs and the marsh of Madjen Djedj (table 1).

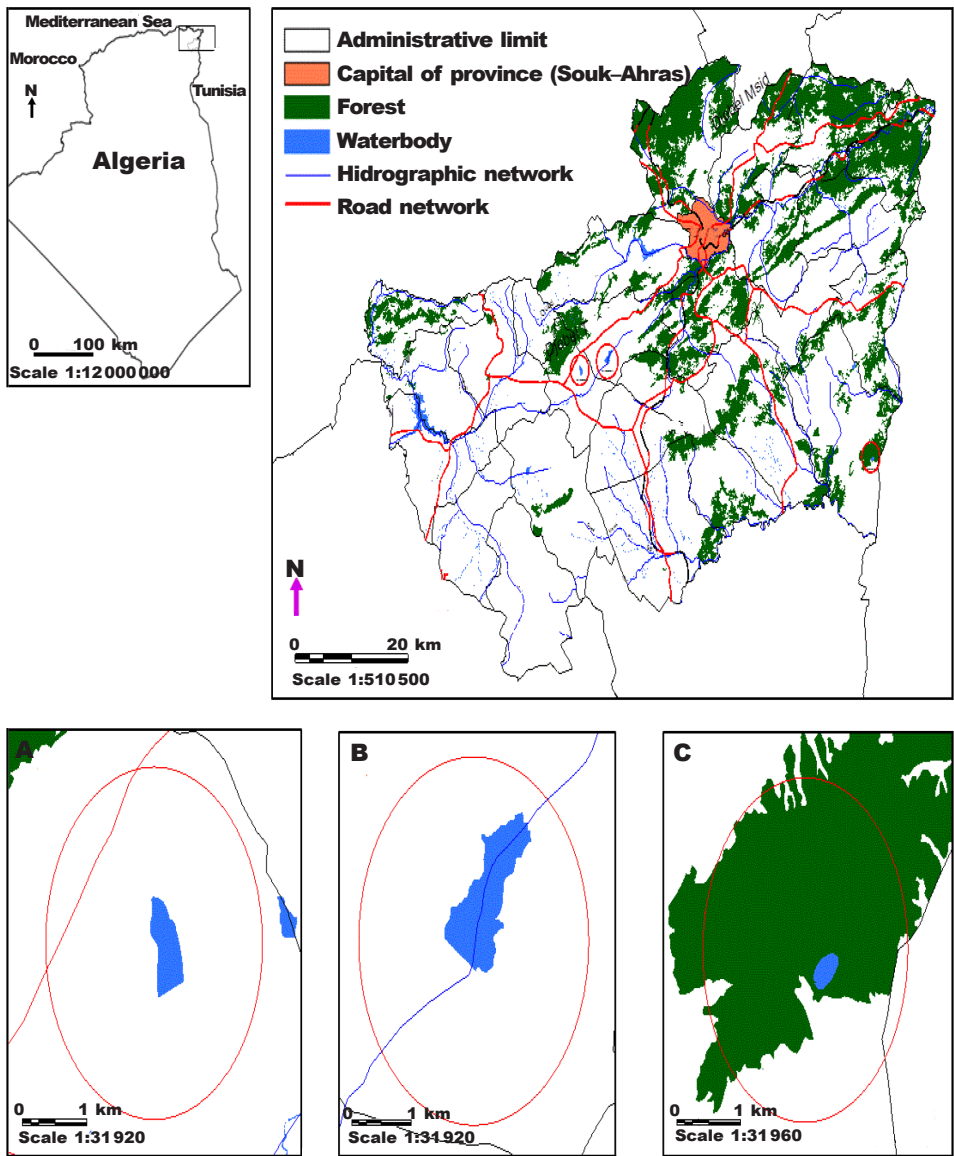


Fig. 1. The geographical location of the three studied wetlands in the wilaya of Souk-Ahras in north-eastern Algeria: A, El-kaf hillside reservoir; B, Tiffech hillside reservoir; C, Madjen Djedj marsh. (The geographic coordinates and physical characteristics of each site are shown in table 1).

Fig. 1. Localización geográfica de los tres humedales estudiados en la wilaya de Souk-Ahras, noreste de Argelia: A, embalse El-kaf; B, embalse Tiffech; C, marisma Madjen Djedj. (Las coordenadas geográficas y características físicas de cada emplazamiento se muestran en la tabla 1).

Table 1. Geographical coordinates and physical characteristics of the studied wetlands in the wilaya of Souk–Ahras north–eastern Algeria. Floral species were obtained from Guellati et al. (2014) and Benradia et al. (2018).

Tabla 1. Coordenadas geogràfiques y características físicas de los tres humedales estudiados de la wilaya de Souk–Ahras, en el noreste de Argelia. Las especies de flora proceden de Guellati et al. (2014) y Benradia et al. (2018).

Site	Coordinates	Area (ha)	Depth (m)	Abundant floral species
El–kaf hillside reservoir	36°08'18.8" 7°43'37.8"	6	3–6	<i>Typha angustifolia</i> <i>Scirpus maritimus</i> <i>Phragmites australis</i>
Tiffech hillside reservoir	36°08'50.6" 7°45'27.7"	110	3–8	<i>Typha angustifolia</i> <i>Scirpus maritimus</i> <i>Phragmites australis</i>
Madjen Djedj marsh	36°01'31.2" 8°14'27.1"	3	2	<i>Atriplexe halimus</i> <i>Typha angustifolia</i> <i>Scirpus maritimus</i> <i>Phragmites australis</i> <i>Pinus halepensis</i>

Sampling

The phenology and structure of the Anatidae population was monitored bi–monthly over 12 months, from September 2019 to August 2020. Our counts allowed an individual count when the flock of waterbirds was close to the point. When the number of individuals was less than 200, we counted them individually. When the number of individuals was greater than 200 or at a greater distance, we made a visual estimate (Lamotte and Bourlière, 1969; Blondel, 1975; Houhamdi, 2002). The counts were carried out by direct observation using a KONUSPOT 20–60x80 telescope. The estimated total number represents the sum of all flock numbers (Houhamdi and Samraoui, 2001, 2002, 2008; Aissaoui et al., 2011). This method often has an estimated margin of error among professionals of 5–10%. It also depends on the observers' experience and the quality of the optical equipment used (Legendre and Legendre, 1979; Tamisier and Dehorter, 1999). To characterize the waterbird community, a few ecological indices were calculated, namely the total abundance, species richness, the Shannon and Weaver diversity index (H') and the index of fairness (E) (Chessel et al., 2004).

The second part of our study consisted of monitoring the rhythm of the daily activities of Anatidae. We used the the SCAN method, carried out every hour, from 9 a.m. to 4 p.m. (Baldassare et al., 1988; Losito et al., 1989; Tamisier and Dehorter, 1999; Boulekhssaim et al., 2006). The activities monitored were feeding, sleeping, swimming, grooming, flight, courtship, and antagonism (Houhamdi and Samraoui, 2001, 2002, 2008; Metallaoui et al., 2009).

Statistical analysis

We used R 3.5.2 (R Development Core Team, 2019) provided with the FactoMineR package. Data were expressed as mean \pm SD for analysis. The Shannon and Weaver diversity index (H') and equitability index (E) were calculated using ADE software (Chessel et al., 2004). Species are presented in the systematic order of Sibley and Monroe (1990). To conduct comparisons of diversity indices across the three sites, we applied the Kruskal–Wallis test (nonparametric alternative to ANOVA), first because our data did not meet the normality and homoscedasticity assumptions, and second to assess the difference in abundance across sites.

Results

Phenology of species

During the wintering season, the three natural wetlands were visited by a total of 13 species showing different phenological status. Six species (46%) were overwintering (*Anas clypeata*, *Anas penelope*, *Anas strepera*, *Tadorna tadorna*, *Aythya ferina*, and *Anas crecca crecca*), three species (23%) were sedentary nesting species (*Anas platyrhynchos*, *Oxyura leucocephala*, and *Aythya nyroca*) and four (31%) were occasional visitor species (passing visitors) (*Anas crecca crecca*, *Marmaronetta angustirostris*, *Anas querquedula*) (table 2, fig. 2, dataset published through GBIF, Doi: [10.15470/fozdot](https://doi.org/10.15470/fozdot)).

Seasonal pattern of abundance

Throughout our regular counts between September 2019 and August 2020, we recorded considerable fluctuations in the population size of the Anatidae. The highest numbers were noted during January and February at all three sites. Tiffrech hillside reservoir showed the largest populations, with a maximum of 1,002 individuals (fig. 3). The other two sites, El-kaf hillside reservoir and Madjen Djedj marsh, had lower numbers, hosting a maximum in January of 264 and 172 individuals, respectively. In this regard, we found a highly significant difference in abundance between sites (Kruskal–Wallis test, $\chi^2 = 90.151$, $P < 0.001$) (fig. 4).

Variations of species richness

The difference in species richness between sites was significant (Kruskal Wallis test, $\chi^2 = 48.427$, $P < 0.01$) (fig. 4). Highest richness was recorded at Tiffrech hillside reservoir with a maximum of thirteen species, including twelve in January and February 2020. The lowest richness was recorded at Madjen Djedj marsh (10 species), with a maximum of nine in February.

Study of the rhythm of daytime activities

Monitoring the rhythm of the diurnal activities of Anatidae was dominated by sleeping, which represented almost half the time allocated to all behaviors (48.91%). This activity was followed by swimming (18.82%), then, respectively, grooming (13.91%) and feeding activity (12.09%). A small proportion of time was allocated to activities such as flight, courtship, and antagonism (fig. 5).

Analysis of the settlement structure

Throughout the study period calculation of the Shannon and Weaver diversity index (H') indicated that Madjen Djedj marsh had the highest values, exceeding 2 bits, with a maxi-

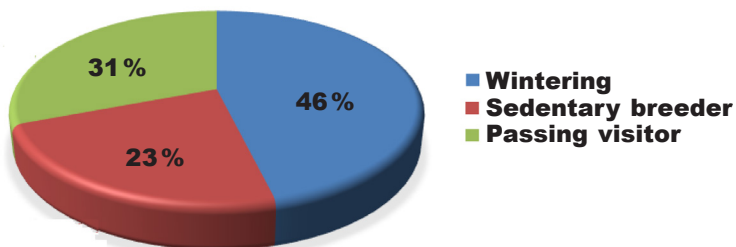


Fig. 2. The phenological status of the different Anatidae species found in the three studied wetlands in the wilaya of Souk–Ahras.

Fig. 2. Estatus fenológico de las diferentes especies de Anatidae registradas en los tres humedales estudiados de la wilaya de Souk–Ahras.

imum of 2.67 bits in February. This maximum corresponds to a species richness of nine species for 155 individuals (fig. 6). Tiffetch hillside reservoir presented low values of H', which resulted in an imbalance in species abundance in the community where two species dominated the total abundance, namely the mallard (*Anas platyrhynchos*) and the common pochard (*Aythya ferina*). At most sites, equitability was recorded at the beginning of the wintering period and during the breeding period when the total numbers were represented by the mallard and the common or greater scaup.

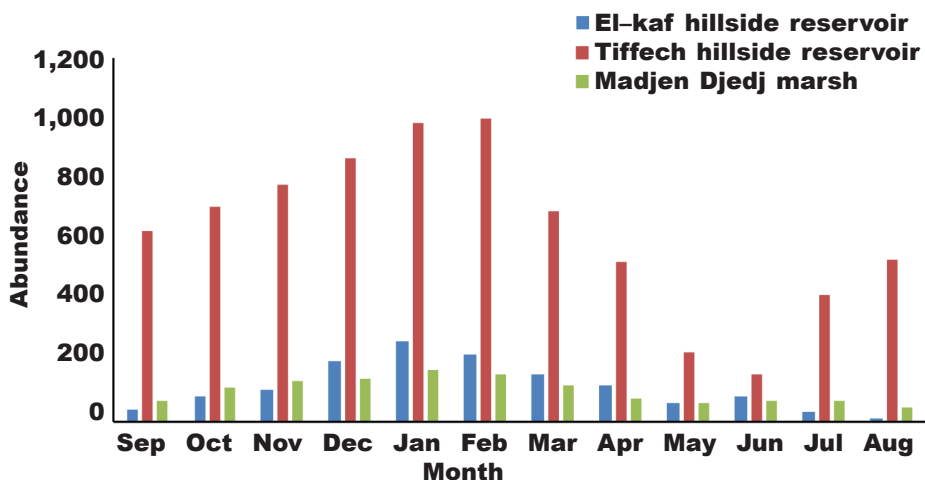


Fig. 3. Annual variation in the abundance of Anatidae species between September 2019 and August 2020 in the three studied sites.

Fig. 3. Variación anual de la abundancia de especies de Anatidae entre septiembre de 2019 y agosto de 2020 en los tres emplazamientos estudiados.

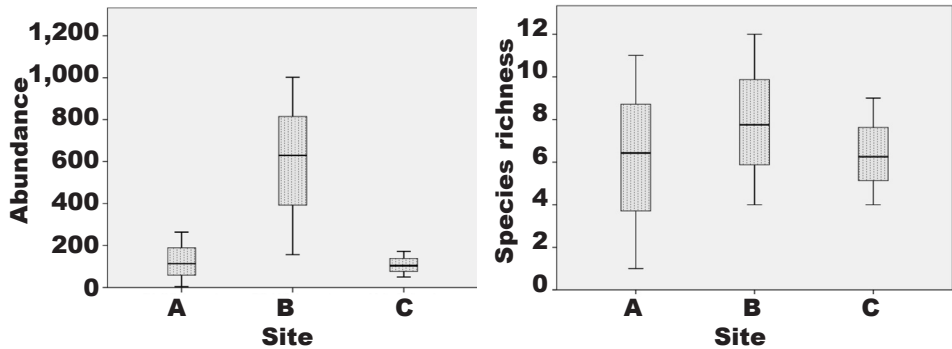


Fig. 4. Variations in the abundance and species richness of Anatidae across the three sites: A, El-kaf hillside reservoir; B, Tiffrech hillside reservoir; C, Madjen Djedj marsh.

Fig. 4. Variación de la abundancia y de la riqueza específica de Anatidae en el conjunto de los tres emplazamientos: A, embalse El-kaf; B, embalse Tiffrech; C, marisma Madjen Djedj.

Discussion

The wetlands of the wilaya of Souk–Ahras retain are of high ecological value, particularly for the population of Anatidae, which they harbor year round. The richness of wintering and nesting waterbird species demonstrates the crucial role of these sites in ecosystem functioning.

The Anatidae family is the third largest group in number of species in Algeria after the Rallidae and Podicipidae family. During our study, we identified thirteen species of birds; three regularly reproduce in these water bodies (*Anas platyrhynchos*, *Oxyura leucocephala*, *Aythya nyroca*), and represent about half of the population of breeding Anatidae at the national scale, which is seven in Algeria (De Balsac and Mayaud, 1962; Isenmann and Moali, 2000). The presence of large numbers of the two endangered species, the black scaup (*Aythya nyroca*) and the white-headed duck (*Oxyura leucocephala*), which nest in very few areas at the national level (Boumezbear, 1993; Houhamdi and Samraoui, 2002; Houhamdi et al., 2009; Metallaoui and Houhamdi, 2008, 2010; Aissaoui, 2009; Lazli et al., 2011a, 2011b; Chettibi et al., 2013) make these areas important sites for their conservation. Of particular note, we point out that most Algerian wetland complexes are frequented by 15 species of Anatidae (Chalabi and Belhadj, 1995; Mettallaoui and Houhamdi, 2010; Baaziz et al., 2011; Seddik et al., 2012; Boudraa et al., 2014; Elafri et al., 2017), which is similar to the number of species recorded at our sites. Besides the species richness, the studied sites harbored a large number of waterfowls, reaching a maximum number of 1,002 winter individuals.

Analysis of the phenological status of aquatic avifauna in this region showed that 46% of the recorded species in these environments have a wintering status, giving the region the role of a favorable wintering area for aquatic avifauna, particularly for species that were observed at such time in large numbers, such as the mallard (*Anas platyrhynchos*), the white-headed duck (*Oxyura leucocephala*) and the common scaup (*Aythya ferina*). The availability and diversity of food resources and the variety of microhabitats in these three study sites provide not only the physical space but also the trophic niche and nesting site for 23% of species that are considered sedentary nesters. These birds seem to prefer large open areas where they

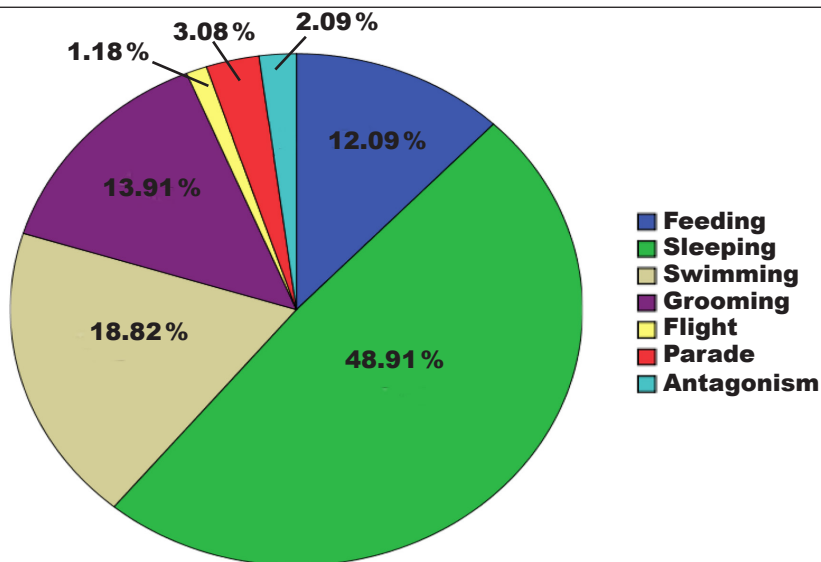


Fig. 5. Proportions of the diurnal activities of Anatidae during the wintering season of 2019–2020 in the three studied wetlands in the wilaya of Souk–Ahras.

Fig. 5. Proporciones de las diferentes actividades diurnas de Anatidae durante la invernada de 2019–2020 en los tres humedades estudiados de la wilaya de Souk–Ahras.

often present particular aggregation, probably seeking low disturbance conditions (Nilsson, 1970; Houhamdi and Samraoui, 2008).

The perennial water and the large size of the Tiffech hillside reservoir site probably explain the greater abundance of waterfowl therein. This was particularly the case for the mallard which is known as a generalist that feeds on emergent vegetation in reed beds and flooded grasslands (Krapu et al., 2006; Steen et al., 2006). Furthermore, the site receives a high rainfall, which is a pivotal environmental feature of wetlands to receive the largest and most diverse populations (Tamisier and Dehorter, 1999; Broyer, 2007; Cherkaoui et al., 2015).

The diurnal time budget monitoring showed a predominance of sleeping behavior, the most common behavior of waterfowl in wintering grounds during the day and a crucial phase to gain mass, reduce energy expenditure, and prepare for reproduction (for sedentary species) or migration (for migratory species) (Green, 1998; Costa and Bondi, 2002; Tucakov, 2005; Boumezbeur et al., 2005). Sleeping also allows these birds to minimize loss of body heat (Tamisier, 1972) in order to withstand the region's occasional cold temperatures during a subhumid bioclimatic stage in a cold winter. The dominance of the sleeping behavior at our study sites indicates the fulfillment of the ecological conditions needed for the waterfowl to winter. Our results concerning the diurnal behavior confirm those previously recorded by Houhamdi and Samraoui (2008) and Metallaoui et al. (2014).

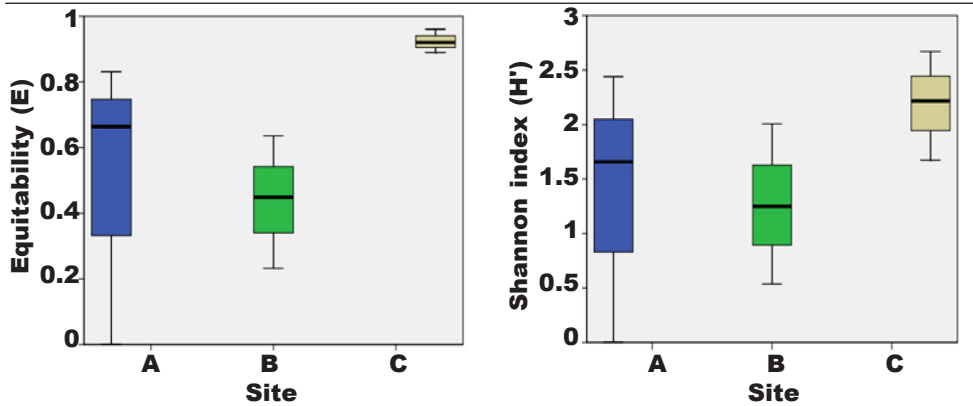


Fig. 6. Variation in the diversity index and the equitability index across sites: A, El-kaf hillside reservoir; B, Tiffetch hillside reservoir; C, Madjen Djedj marsh.

Fig. 6. Variación de los índices de diversidad y equidad en el conjunto de los tres emplazamientos: A, embalse El-kaf; B, embalse Tiffetch; C, marisma Madjen Djedj.

Conclusion

This study, carried out during an annual cycle in three wetlands of the wilaya of Souk-Ahras, helped us to collect important information on the community structure, phenology, and diurnal behavior of Anatidae so as to understand the ecological needs of local waterfowl and better manage these. The different phenological status among the thirteen recorded species highlights the role of these wetlands in welcoming a diverse community of waterbirds in the wintering, stopover, and breeding seasons. Daytime budgets are dominated by sleeping activity, indicating that these wetlands constitute an ideal refuge for the reception of these birds and, like all Algerian wetlands, play an important role in the transit of migratory birds (Houhamdi and Samraoui, 2001, 2002, 2008; Metallaoui et al., 2014; Merzoug et al., 2014; Amor Abda et al., 2015). The presence of two nesting species, *Oxyura leucocephala* and *Aythya nyroca*, protected by Algerian or international legislation, is also an indicator that these sites are of biodiversity importance and should be protected and managed. To this end, it is necessary to establish a management plan based on effective strategies involving law enforcement, surveillance, regular monitoring, and public awareness-raising for the protection of these threatened species.

Acknowledgements

We thank the reviewers for their comments and suggestions, Dr. Rassim Khelifa and Pr. Kerfouf Ahmed for their comments and suggestions on the manuscript, and the MERS and the DGRSDT for supporting and funding this work.

References

- Aissaoui, R., 2009. Eco-éthologie des Anatidés dans la Numidie orientale: cas de la Fuligule nyroca *Aythya nyroca* dans le Lac Tonga. PhD thesis, Badji Mokhtar University, Annaba, Algeria.
- Aissaoui, R., Houhamdi, M., 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., Tahar, A., Saheb, M., Guergueb, L., Houhamdi, M., 2011. Diurnal behaviour of Ferruginous Duck *Aythya nyroca* wintering at the El-Kala wetlands (northeast Algeria). *Bulletin de l'Institut Scientifique, Rabat, section Sciences de la Vie*, 33(2): 67–75.
- Amor Abda, W., Merzoug, S., Belhamra, M., Houhamdi, M., 2015. Phenology and diurnal behaviour of the Northern Shoveler *Anas clypeata* in the Guerbes-Sanhadja wetland complex (north-eastern Algeria). *Zoology and Ecology*, 25(1): 19–25.
- Atoussi, S., Rezkallah, I., Khemis, M. D. E., Merzoug, A., Telailia, S., Houhamdi, M., 2017. Nouvelles données sur l'hivernage de l'Érismature à tête blanche *Oxyura leucocephala* en Algérie. *Alauda*, 85(1): 29–36.
- Baaziz, N., Mayache, B., Saheb, M., Bensaci, E., Ounissi, M., Metallaoui, S., Houhamdi, M., 2011. Statut phénologique et reproduction des peuplements d'oiseaux d'eau dans l'éco-complexe de zones humides de Sétif (Hauts plateaux, Est de l'Algérie). *Bulletin de l'Institut Scientifique de Rabat*, 32(2): 77–87.
- Baaziz, N., Samraoui, B., 2008. The status and diurnal behaviour of wintering common coot *Fulica atra* L. in the Hauts Plateaux, Northeast Algeria. *European Journal of Scientific Research*, 23(3): 495–512.
- Baldassarre, G. A., Paulus, S. L., Tamisier, A., Titman, R. D., 1988. Workshop summary: techniques for timing activity of wintering waterfowl. In: *Waterfowl in winter*: 181–188 (M. W. Weller, Ed.). University of Minnesota Press, Minneapolis, USA.
- Bara, M., Eddine, M. S., Khelifa, R., Bouslama, Z., Houhamdi, M., 2014. Aspects of the breeding ecology of the Purple Swamphen *Porphyrio porphyrio* in the wetland complex of Guerbes-Sanhadja, north-east Algeria. *Ostrich*, 85(2): 185–191
- Benradia, M., Mena, M., Guellati, K., Maazi, M. C., Bouslama, Z., Houhamdi, M., 2018. Ecologie des Anatidés et du foulque macroule *Fulica atra* dans les zones humides de la wilaya de Souk-Ahras (nord-est de l'Algérie). *Bulletin de la Société zoologique de France*, 143(3): 145–169.
- Blondel, J., 1975. L'analyse des peuplements d'oiseaux, éléments d'un diagnostic écologique I. la méthode des échantillonnages fréquentiels progressifs (EFP). *La Terre et la Vie*, 29: 533–289.
- Boudraa, W., Bouslama, Z., Houhamdi, M., 2014. Inventaire et écologie des oiseaux d'eau dans le marais de Boussehra (Annaba, nord-est de l'Algérie). *Bulletin de la Société zoologique de France*, 139(1–4): 279–293.
- Boukrouma, N., Maazi, M. C., Saheb, M., Metallaoui, S., Houhamdi, M., 2011. Hivernage du canard pilet *Anas acuta* sur les hauts plateaux de l'est de l'Algérie. *Alauda*, 79(4): 285–293.
- Boulkhsaim, M., Houhamdi, M., Saheb, M., Samraoui, F., Samraoui, B., 2006. Breeding and banding of Greater Flamingo *Phoenicopterus roseus* in Algeria. *Flamingo Bulletin*, 14: 21–24.
- Boumezbeur, A., 1993. Ecologie et biologie de reproduction de l'erismature a tete blanche (*Oxyura leucocephala*) et de fuligule nyroca (*Aythya nyroca*) sur le lac tonga et le lac oiseaux (est-algerien). (mesures de protection et de gestion du lac tonga). PhD thesis, École Pratique des Hautes Études, Paris, France.
- Boumezbeur, A., Moali, A., Isenmann, P., 2005. Nidification du fuligule nyroca *Aythya nyroca* et de l'échasse blanche *Himantopus himantopus* en zone saharienne (El Goléa, Algérie). *Alauda*, 73(2): 143–144.
- Broyer, J., 2007. Nidification des anatidés en France: analyse des variations dans les

- principales régions. *Faune Sauvage*, 277: 4–11.
- Carignan, V., Villard, M. A., 2002. Selecting indicator species to monitor ecological integrity: a review. *Environmental Monitoring and Assessment*, 78(1): 45–61.
- Chalabi, B., Belhadj, G., 1995. Distribution géographique et importance numérique des Anatidés, foulques, flamants et grues hivernant en Algérie. *Annales de l'Institut national agronomique El Harrach*, 16(1): 83–96.
- Cherkaoui, S. I., Hanane, S., Magri, N., El Agbani, M. A., Dakki, M., 2015. Factors influencing species–richness of breeding waterbirds in Moroccan IBA and Ramsar wetlands: a macroecological approach. *Wetlands*, 35(5): 913–922.
- Chessel, D., Dufour, A. B., Thioulouse, J., 2004. The ade4 package—One–table methods. *R News*, 4(1): 5–10.
- Chettibi, F., Khelifa, R., Aberkane, M., Bouslama, Z., Houhamdi, M., 2013. Diurnal activity budget and breeding ecology of the White–headed Duck *Oxyura leucocephala* at Lake Tonga (North–east Algeria). *Zoology and Ecology*, 23(3): 183–190.
- Costa, M., Bondi, S., 2002. Status e biologia della Moretta tabaccata *Aythya nyroca*, nel complesso palustre di Punte Alberete e Valle Mandriole (Ravenna). *Rivista Italiana di Ornitologia*, 71(2): 125–131.
- De Balsac, H. H., Mayaud, N., 1962. *Les oiseaux du nord–ouest de l'Afrique: distribution géographique, écologie, migrations, reproduction*, Vol. 10. P. Lechevalier, Paris
- Elafri, A., Belhamra, M., Houhamdi, M., 2017. Comparing habitat preferences of a set of waterbird species wintering in coastal wetlands of North Africa: implication for management. *Ekológia (Bratislava)*, 36(2): 158–171.
- Green, A. J., 1998. Comparative feeding behaviour and niche organization in a Mediterranean duck community. *Canadian Journal of Zoology*, 76(3): 500–507.
- Guellati, K., Maazi, M. C., Benradia, M., Houhamdi, M., 2014. Le peuplement d'oiseaux d'eau du complexe des zones humides de la wilaya de Souk–Ahras: état actuel et intérêt patrimonial. *Bulletin de la Société zoologique de France*, 139(1–4): 263–277.
- Guergueb, E., Bensaci, E., Nouidjem, Y., Zoubiri, A., Kerfouf, A., Houhamdi, M., 2014. Aperçu sur la diversité des oiseaux d'eau du chott El–Hodna (Algérie). *Bulletin de la Société zoologique de France*, 139(1–4): 233–244.
- Halassi, I., Elafri, A., Belhamra, M., Houhamdi, M., 2016. Répartition et abondance de l'Érismature à tête blanche *Oxyura leucocephala* dans les zones humides du Nord–Est algérien. *Alauda*, 84(1): 23–32.
- Houhamdi, M., 2002. Ecologie des peuplements aviens du Lac des Oiseaux (Numidie orientale). PhD thesis, Badji Mokhtar University, Annaba, Algeria.
- Houhamdi, M., Samraoui, B., 2001. Diurnal time budget of wintering Teal *Anas crecca* at Lac des Oiseaux, northeast Algeria. *Wildfowl*, 52: 87–96.
- 2002. Occupation spatio–temporelle par l'avifaune aquatique du Lac des Oiseaux (Algérie). *Alauda*, 70(2): 301–310.
- 2008. Diurnal and nocturnal behaviour of ferruginous duck *Aythya nyroca* at Lac des Oiseaux, northern Algeria. *Ardeola*, 55(1): 59–69.
- Houhamdi, M., Hafid, H., Seddik, S., Bouzegag, A., Nouidjem, Y., Bensaci, T., Maazi, M. C., Saheb, M., 2008. Hivernage des grues cendrées *Grus grus* dans le complexe des zones humides des hautes plaines de l'Est algérien. *Aves*, 45(2): 93–103.
- Houhamdi, M., Maazi, M. C., Seddik, S., Bouaguel, L., Bougoudjil, S., Saheb, M., 2009. Statut et écologie de l'Érismature à tête blanche (*Oxyura leucocephala*) dans les hauts plateaux de l'Est de l'Algérie. *Aves*, 46(1): 129–148.
- Ilsenmann, P., Moali, A., 2000. *Oiseaux d'Algérie. Birds of Algeria*. Société d'Etudes Ornithologiques de France, Paris, France.
- Khelifa, R., 2012. Cartography of the dispersal of Glossy ibis (*Plegadis falcinellus*). Magister thesis, Université de 08 Mai 1945, Guelma, Algeria.

- Khelifa, R., Zebba, R., Amari, H., Mellal, M. K., Mahdjoub, H., Kahalerras, A., 2016. A hotspot for threatened Mediterranean odonates in the Seybouse River (Northeast Algeria): are IUCN population sizes drastically underestimated? *International Journal of Odonatology*, 19(1–2): 1–11.
- Krapu, G. L., Pietz, P. J., Brandt, D. A., 2006. Mallard brood movements, wetland use, and duckling survival during and following a prairie drought. *The Journal of Wildlife Management*, 70(5): 1436–1444.
- Lamotte, M., Bourlière, F. (Eds.), 1969. *Problèmes d'Écologie: l'échantillonnage des peuplements animaux des milieux terrestres*. Masson et Cie, Paris.
- Lazli, A., Boumezbeur, A., Moali-Grine, N., Moali, A., 2011a. Évolution de la population nicheuse de l'Érismature à tête blanche *Oxyura leucocephala* sur le lac Tonga (Algérie). *Revue d'Ecologie (La Terre et la Vie)*, 66: 173–181.
- Lazli, A., Boumezbeur, A., Perennou, C., Moali, A., 2011b. Biologie de la reproduction de l'Érismature à tête blanche *Oxyura leucocephala* au lac Tonga (Algérie). *Revue d'Ecologie (La Terre et la Vie)*, 66: 255–265.
- Legendre, L., Legendre P., 1979. *Ecologie numérique: la structure des données écologiques*, Tome 2. Masson, Paris et les Presses de l'Université du Québec, <https://doi.org/10.1002/iroh.19810660515>
- Losito, M. P., Mirarchi, R. E., Baldassarre, G. A., 1989. New techniques for time–activity studies of avian flocks in view–restricted habitats. *Journal of Field Ornithology*, 60(3): 388–396.
- Maazi, M. C., 2005. Eco–éthologie des Anatidés hivernants dans la garaet de Timerganine (Oum El–Bouaghi). Magister thesis, University Oum El–Bouaghi, Algeria.
- 2009. Eco–éthologie des Anatidés hivernants dans l'étang de Timerganine (Ain Zitoune, Wilaya d'Oum El–Bouaghi). PhD thesis, Badji Mokhtar University, Annaba, Algeria.
- Maazi, M. C., Saheb, M., Bouzegag, A., Seddik, S., Noudjem, Y., Bensaci, E. Houhamdi, M., 2010. Ecologie de la reproduction de l'Echasse blanche *Himantopus himantopus* dans la Garaet de Guellif (Hauts plateaux de l'Est algérien). *Bulletin de l'Institut Scientifique de Rabat*, 32(2): 101–109.
- Mayache, B., Houhamdi, M., Samraoui, B., 2005. Ecologie des Sarcelles d'hiver *Anas crecca crecca* L. hivernants dans l'éco–complexe de zones humides de Jijel (Nord–Est de l'Algérie). *European Journal of Scientific Research*, 21: 104–119.
- Merzoug, S. E., Amor Abda, W., Belhamra, M., 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.
- Metallaoui, S., 2010. Écologie de l'avifaune aquatique hivernante dans Garaet Hadj Tahar (Numidie occidentale, Nord–est de l'Algérie). PhD thesis, Université Badji Mokhtar d'Annaba, Algeria.
- Metallaoui, S., Atoussi, S., Merzoug, A., Houhamdi, M., 2009. Hivernage de l'Érismature à tête blanche (*Oxyura leucocephala*) dans Garaet Hadj–Tahar (Skikda, nord–est de l'Algérie). *Aves*, 46(3): 136–140.
- Metallaoui, S., Houhamdi, M., 2008. Données préliminaires sur l'avifaune aquatique de la Garaet Hadj–Tahar (Skikda, Nord–Est algérien). *Bulletin of the African Bird Club*, 15(1): 71–76.
- 2010. Biodiversité et écologie de l'avifaune aquatique hivernante dans Garaet Hadj–Tahar (Skikda, Nord–Est de l'Algérie). *Hydroécologie Appliquée*, 17: 1–16.
- Metallaoui, S., Maazi, M. C., Saheb, M., Houhamdi, M., Barbraud, C., 2014. A comparative study of the diurnal behaviour of the Northern Shoveller (*Anas clypeata*) during the wintering season at Garaet Hadj–Tahar (North–East Algeria) and Garaet Timerganine (Algerian highlands). *Turkish Journal of Zoology*, 38(2): 158–167.
- Nilsson, L., 1970. Food–seeking activity of south Swedish diving ducks in the non–breeding season. *Oikos*, 21(2): 145–154.
- R Development Core Team, 2019. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.

- Saheb, M., 2009. Ecologie de la reproduction de l'échasse blanche *Himantopus himantopus* et de l'avocette élégante *Recurvirostra avosetta* dans les hautes plaines de l'est algérien. PhD thesis, Badji Mokhtar University, Annaba, Algeria.
- Saheb, M., Bouzegag, A., Nouidjem, Y., Bensaci, T., Samraoui, B., Houhamdi, M., 2009. Ecologie de la reproduction de l'Avocette élégante *Recurvirostra avosetta* dans la Garaet de Guellif (Hautes plaines de l'Est algérien). *European Journal of Scientific Research*, 25(4): 513–525.
- Samraoui, B., De Belair, G., 1998. Les zones humides de la Numidie orientale: bilan des connaissances et perspectives de gestion. *Synthèse*, 4: 1–90.
- Samraoui, F., Samraoui, B., 2008. The reproductive ecology of the Common Coot (*Fulica atra*) in the Hauts Plateaux, northeast Algeria. *Waterbirds*, 30(1): 133–139.
- Seddik, S., Bouaguel, L., Bougoudjil, S., Maazi, M. C., Saheb, M., Metallaoui, S., Houhamdi, M., 2012. L'avifaune aquatique de la Garaet de Timerganine et des zones humides des Hauts Plateaux de l'Est algérien. *Bulletin of the African Bird Club*, 19(1): 25–32.
- Sibley, C., Monroe, B., 1990. *Distribution and Taxonomy of Birds of the World*. Yale University Press, UK.
- Steen, D. A., Gibbs, J. P., Timmermans, S. T., 2006. Assessing the sensitivity of wetland bird communities to hydrologic change in the eastern Great Lakes region. *Wetlands*, 26(2): 605–611.
- Tamisier, A., 1972. Etho-écologie des sarcelles d'hiver (*Anas c. crecca* L.) pendant leur hivernage en Camargue. PhD thesis, Académie de Montpellier, Université des sciences et techniques du Languedoc, France.
- Tamisier, A., Dehorter, O., 1999. *Camargue, canards et foulques: fonctionnement et devenir d'un prestigieux quartier d'hiver*. Centre ornithologique du Gard, Nîmes.
- Temple, S. A., Wiens, J. A., 1989. Bird populations and environmental changes: can birds be bio-indicators. *American Birds*, 43(2): 260–270.
- Tucakov, M., 2005. Migration of common pochard *Aythya ferina* and ferruginous duck *Aythya nyroca* on Kolut Fishpond (Northern Serbia). *Aquila*, 112: 15–22.