A multi-year survey on aquatic avifauna consolidates the eligibility of a small significant peri-urban wetland in northeast Algeria to be included on the IBA network

Khalil Draidi  
University of Badji Mokhtar

Imed Djemadi  
Environmental Research Center, Algeria

Badis Bakhouche  
Houari Boumediene University of Science and Technology

Souad Narsis  
Environmental Research Center, Algeria

Zihad Bouslama  
Environmental Research Center, Algeria

Abdenour Moussouni  
National high college of forestry

Ghoulem Tiar (✉ tiarghoulem@yahoo.fr)  
Environmental Research Center, Algeria

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Abstract

To date, Algeria has twenty-two wetlands designated as Important Bird Areas (IBA). However, other wetlands are also eligible for this network but have not yet been classified due to a lack of comprehensive studies demonstrating their ornithological importance. In this study, we are interested in the Boussedra marsh, located on the Algerian coast in the far northeast. IBA categories A1 and A4i were found to be significant, confirming the international importance of this wetland for waterbirds. Five species inhabiting the site are listed as globally threatened on the IUCN red list, namely, Oxyura leucocephala (Endangered), Aythya nyroca (Near Threatened), Vanellus vanellus (Near Threatened), Aythya ferina (Vulnerable) and Marmaronetta angustirostris (Vulnerable). Interestingly, Oxyura leucocephala was recorded with more than 10% of the world's population. Overall, the avian community of Boussedra inventoried between September 2015 and August 2018, has reached a diversity of 42 species, i.e., one-third of the national aquatic avifauna, consisting mainly of surface ducks, Rallids, waders, gulls and raptors, making it one of the ten most diverse wetlands in the country. Although the monthly numbers of waterbirds in the marsh are low compared to the large Algerian sites (< 5000 individuals), they are still among the most important locally. Boussedra is a real wintering area, but it is also home to a diverse nesting population of 20 species, including four that are globally threatened according to the IUCN Red List, making it one of the most important nesting areas for waterbirds in Algeria.

Introduction

Western Palearctic waterbirds leave their northwest European summering grounds to spend the winter, after a post-nuptial period, mainly in northwest and sub-Saharan Africa (Algeria, Morocco, Tunisia, Chad, Niger, western Mauritania) (Stevenson et al. 1988). A wide diversity of birds belonging to different taxonomic groups (ducks, waders, grebes, etc.) are found in most of these wintering areas. When they find suitable conditions for breeding, they may prolong their stay and tend to become sedentary (Boukhssaim et al. 2006; Samraoui and Samraoui 2008). Birds migrating further south also prefer to stopover in north Africa, seen as an intermediate area to compensate for the energy lost in the effort required to migrate (Stevenson et al. 1988). Algeria's geographical location and the diversity of its wetlands give it a strategic position between the northern and southern hemispheres. This makes it an area of exchange and strategic importance for the dynamics of the world's birds. Several Algerian wetlands have been identified as important wintering, breeding and stopover areas for migratory waterbirds of the western Palearctic (Baziz et al. 2011; Bensaci et al. 2013; Yahiacherif-Sadaoui 2015; Beghdadi 2016; Sahbi et al. 2018; Senoussi 2019; Bediaf et al. 2020; Loucif et al. 2020).

Some of these wetlands have been identified as being of international importance for many endangered waterbirds, rare species or species restricted to a limited biome, and are therefore under protection. There are fifty Ramsar wetlands throughout Algeria, nineteen of which have been designated Important Bird Areas (IBA) under the BirdLife international organization that strives to conserve birds and their habitats (Ramsar convention website 2023; BirdLife International Website 2023). Algeria has a total of twenty-two wetlands officially registered in the IBA network. A further twenty-one eligible wetlands that meet at least one of the BirdLife International criteria have been identified by Samraoui and Samraoui (2008).

In this study, we are particularly interested in one of the eligible and vulnerable IBAs, “Boussedra marsh”, for two main reasons. Firstly, we are convinced that the bio-physical-chemical carrying capacity of birds will be severely affected as a result of its rapid alteration. This water body, located in the middle of an urban region, has experienced an increase in anthropogenic activities; partial destruction of the site by backfilling, pumping and agglomeration expansion around the water body, increase in significant domestic and industrial effluents, poaching (unpublished personal data). Secondly, the data that we will collect over three years will provide a scientific basis to support the desirable project of including the Boussedra marsh in the IBA network, particularly about globally threatened bird species. Neither the study by Samraoui and Samraoui (2008) nor, to the best of our knowledge, other studies before this one, e.g., (Abekane et al. 2013; Chettibi 2014; Belabled-Zediri et al. 2020; Aouadi 2022; Talbi 2022), have detailed the annual ornithological potential of this site. The data collected over three years will allow us to assess the dynamics of the site's capacity to support the species.

Based on several years of monitoring, we have analysed the composition and structure of the aquatic avifauna of the Boussedra marsh. This will provide an assessment of its current potential to meet the eligibility requirements of international nature conservation organisations, mainly the IBA network.
Materials and Methods

Study site

The Boussedra marsh is an unprotected freshwater body located in the province of Annaba in the extreme northeast of Algeria (36°50′45″ N, 7°43′47″ E) (Fig. 1). It extends over a maximum area of about 55 ha, which varies according to the intensity of precipitation within seasons and years (Chettibi 2014). The study area was located on the warm sub-humid meso-Mediterranean bioclimatic floor, rainy in winter and hot and dry in summer (5 m above sea level). The mean annual temperature was 17°C, and the mean annual total rainfall was 630 mm, according to the nearest meteorological stations. The mean relative humidity exceeds 70% due to the sea spray and the numerous nearby wetlands.

The vegetation on the four sides of the lake, and on the numerous islets is mainly dominated by *Scirpus maritimus*, *Scirpus lacustris*, Lesser bulrush, *Typha angustifolia*, *Phragmites australis* and *Tamarix gallica*.

Data collection

The monitoring of the aquatic avifauna was carried out from September 2015 to August 2018 at a rate of two visits per month. Visual observations were made with a Konus-Spot ornithological telescope (20×60) and Soligor binoculars (15×45). We applied the absolute count technique by exhaustive counting when the group of birds contained less than 200 individuals. For the largest groups, we chose to estimate the numbers. Counts were made from a high point on one of the banks overlooking the whole marsh.

Avifauna description parameters

The frequencies of occurrence F% per taxon *i* is a measure of the presence of a species in an environment, calculated using the formula (1) (Dajoz 1976):

\[
F\% = \frac{(R_i \times 100)}{R}, \quad (1)
\]

Where; \( R_i \) = number of samples where species *i* was present, \( R \) = total number of samples. Depending on the value of F%, the following categories are distinguished: Frequent when \( F\% \geq 75\% \), common when \( 75\% > F\% \geq 50\% \), occasional when \( 50\% > F\% \geq 25\% \), rare when \( 25\% > F\% \geq 10\% \), and accidental when \( F\% < 10\% \).

The Shannon diversity index quantifies the heterogeneity of biodiversity in an environment and tracks its evolution over time (Blondel 1975). It was calculated as follows (2):

\[
H' = - \sum [(p_i) \times \log_2 (p_i)], \quad (2)
\]

Where; \( p_i \) was the proportion of individuals of one particular species found divided by the total number of individuals of all species recorded, \( \log_2 \) was the base-2 logarithm, \( \sum \) was the sum of the calculations. Equitability was another diversity index determined to assess the evenness of the respective ecosystems. It was calculated according to (Blondel 1975), using the Eq. (3);

\[
E = \frac{H'}{H'_{\text{Max}}}, \quad (3)
\]

Where; \( H' \) was the Shannon diversity index, and \( H'_{\text{Max}} \) was the base-2 logarithm of the total number of species (S) in the sampled ecosystem (\( \log_2 S \)).

Results

Taxonomic richness
Monitored over three annual cycles, the waterbird community of the Boussedra marsh reached a diversity of 42 species, with a minimum of 35 species per year. The site hosted up to 30 different species (with a minimum of 25) during the summer periods, and a maximum of 41 species (with a minimum of 28) during the winter periods (Fig. 2).

A total of 12 different families of waterbirds were recorded in the present study (Fig. 3). Anatidae was the most represented family, with a diversity of 11 species (26%), followed by the Ardeidae, Chardriidae, Laridae and Rallidae with 4 to 6 species (10–17%), while the diversity of the remaining families had no more than 3 species each (≤5%).

Out of the species occurring at the site, five are globally threatened and appear on the IUCN Red List (Table 1), namely; *Oxyura leucocephala* (Endangered, EN), *Aythya nyroca* (Near Threatened, NT), *Aythya ferina* (Vulnerable, VU), *Marmaronetta angustirostris* (VU), and *Vanellus vanellus* (NT).

### Table 1
Comparison of the Maximal abundance in the winter period and the nest number for five Threatened + one Least Concern (LC) waterbirds between Boussedra marsh and Algerian bibliographic records

<table>
<thead>
<tr>
<th>Species</th>
<th>Global threatened status</th>
<th>Maximal specific abundance in winter period</th>
<th>Maximal nest numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Present study</td>
<td>Algerian record</td>
</tr>
<tr>
<td>White headed Duck</td>
<td>EN</td>
<td>960</td>
<td>1.100</td>
</tr>
<tr>
<td>Ferruginous Duck</td>
<td>NT</td>
<td>136</td>
<td>3.642</td>
</tr>
<tr>
<td>Common Pochard</td>
<td>VU</td>
<td>420</td>
<td>1.600</td>
</tr>
<tr>
<td>Marbled Teal</td>
<td>VU</td>
<td>25</td>
<td>1.050</td>
</tr>
<tr>
<td>Northern Lapwing</td>
<td>NT</td>
<td>820</td>
<td>1.500</td>
</tr>
<tr>
<td>Glossy Ibis</td>
<td>LC</td>
<td>199</td>
<td>201</td>
</tr>
</tbody>
</table>

In each row from left to right, the table displays the species, its global threatened status, the Maximal specific abundance in the winter period and the Maximal nest numbers, in both two last, the present study and the Algerian record.

Total, specific and relative monthly abundances

The monthly abundance of the entire populations frequenting the marsh oscillated between a minimum of 582 individuals, observed at the beginning of the 2015 wintering period, and a maximum of 4,937 individuals noted at the end of the 2017 wintering period (Fig. 4).

Focusing on globally threatened species, we recorded remarkable specific abundance values for two out of five species. During the winter period of 2018, the population of White-headed Duck (EN) reached 960 individuals. The local population of Lapwing (VU) also showed during the same period a large increase, with a peak of 820 individuals. However, the Common Pochard (VU), Marbled Teal (VU), and Ferruginous Duck (NT) were present in smaller numbers, with 420, 136 and 25 individuals, respectively.
Overall, most species showed relative monthly abundances above 10%. Only 8 of the 38 recorded species (21%) exceeded this proportion during the 2016–2017 (the annual cycle 2016–2017 corresponds to the highest abundance of the study period) (Table 2). Two globally threatened species, the White-headed duck and the Crested lapwing, had constantly maintained their relative abundances above 10% of the total studied community, for 7 and 3 months, respectively.

### Table 2 Monthly variation in relative abundance exceeding 10% in at least one month in Boussedra Marsh in 2016-2017 (the annual cycle 2016-2017 corresponds to the highest abundance of the study period)

<table>
<thead>
<tr>
<th>Study period</th>
<th>Winter period</th>
<th>Summer period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sep</td>
<td>Oct</td>
</tr>
<tr>
<td>Eurasian Coot</td>
<td>12%</td>
<td>16%</td>
</tr>
<tr>
<td>Common Moorhen</td>
<td>26%</td>
<td>15%</td>
</tr>
<tr>
<td>White Headed Duck</td>
<td>8%</td>
<td>17%</td>
</tr>
<tr>
<td>Northern Shoveler</td>
<td>-</td>
<td>37%</td>
</tr>
<tr>
<td>Black-Headed Gull</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Western Cattle Egret</td>
<td>3%</td>
<td>-</td>
</tr>
<tr>
<td>Northern Lapwing</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mallard Duck</td>
<td>29%</td>
<td>-</td>
</tr>
</tbody>
</table>

The common name of species is given in the first column, the monthly relative abundance of the winter period was given from September to April, and of the summer period from May to August; Coloured boxes correspond to percentages exceeding 10%; Empty boxes (-) indicate the absence of the species

#### Occurrence frequency

Only 17 species (40% of the recorded avifauna) showed a difference in occurrence frequency in at least one of the three years of the study. In contrast, 25 species (60% of the recorded avifauna) showed no difference. We counted 11 regular sedentary species, representing 26% of the total richness (Table 3 in Appendix A). When taken separately, sedentary species represent 27% and 39% in the summer and winter periods, respectively. Note that we calculated the percentages of frequency of occurrence for each of the two periods separately (combining them gives a higher richness than the real one), because some species that are not necessarily sedentary were found in both summer and winter. In addition to the sedentary species whose presence is annual, the summer periods were characterised by the presence of 6 regular species (21% of the summer species) and 11 accidental or rare species (39% of the summer species), whereas the diversified winter periods were characterised by the presence of 4 regular species (10% of the winter species) and 26 accidental or rare species (63% of the winter species). Thus, no less than 15 regular species were recorded in the Boussedra marsh in winter and 17 in summer. In addition to these species, there were others that were only occasionally or rarely found. The richness of the marsh thus increased to 41 and 28 species, respectively.

#### Diversity indices

The Shannon diversity index revealed a barely average state of equilibrium, slightly better during the winter periods (2.811–2.854 bits) than in summers (1.967–1.987 bits), due to the above-mentioned differences in richness (Fig. 2). The same applies for the equitability index, with average values between 0.42 and 0.58. Overall, the Diversity index values express a variation in the distribution of abundance favouring a limited number of species that can be considered dominant. The average number of dominant species exceeding 10% of the total stand was 8 out of 36 species during the winter periods, compared to only 5 out of 25 species during the summer periods (Table 2). The index values have hardly changed between the study periods (Fig. 5) reflecting the stability of the site's receiving conditions during this period.

#### Breeding

Over the three years of the study, we counted 20 species of breeding waterbirds, including 17 regulars and 3 non-regulars (Table 3 in Appendix A). The most remarkable nesters were Glossy Ibis, White-headed Duck, and Ferruginous Duck represented by 43, 38
and 15 nests, respectively. Common Pochard and Marbled Teal had a reduced number of broods do not exceeding 5 nests (Table 1).

Discussion

Taxonomic richness

The Boussedra marsh covers a relatively small area of about fifty-five hectares in years with high rainfall (Chettibi 2014). Its total area has been reduced to half of its original size of almost twenty-eight hectares due to partial backfilling over the last few decades and low water inflows over the same period (Aouadi 2022). The urban expansion around the marsh has tripled in the last two decades, and at the present, the water body is surrounded by concrete on all four sides (Aouadi 2022). However, the marsh continues to host a high richness of 42 species, i.e. a third (32%) of the national aquatic avifauna (130 species), including two new observations of *Egretta gularis* and *Vanellus spinosus* (Telailia et al. 2018; Farhi et al. 2020) following the review by Isenmann and Moali (2000). The significant richness of the site places it among the 10 most diversified wetlands in the country (See Table 4).
<table>
<thead>
<tr>
<th>Region</th>
<th>Site</th>
<th>Surface area (ha)</th>
<th>Maximum number of birds</th>
<th>Recorded Species</th>
<th>Breeding species</th>
<th>Current status</th>
<th>Retained IBA criteria</th>
<th>Retained Ramsar criteria based on waterbirds</th>
</tr>
</thead>
<tbody>
<tr>
<td>East and Central Wetlands</td>
<td>Sebkhet Bazer-Sakra</td>
<td>4379^1</td>
<td>28000^10</td>
<td>79^10</td>
<td>21^10</td>
<td>Ramsar^1, IBA^2</td>
<td>A4i (T. tadorna, P. roseus)</td>
<td>Cr 2 : (M. angustirostris, O. leucocephala)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cr 4 : (O. leucocephala, P. roseus)</td>
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<td></td>
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<td></td>
<td></td>
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<td></td>
<td>Cr 6 : (T. tadorna, P. roseus)</td>
</tr>
<tr>
<td></td>
<td>Garaet Timerganine</td>
<td>1460^1</td>
<td>79^14</td>
<td>17^14</td>
<td>Ramsar^1</td>
<td></td>
<td></td>
<td>Cr 2 : (A. nyroca, M. angustirostris, O. leucocephala)</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>Cr 4 : (A. nyroca, M. angustirostris, O. leucocephala)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Cr 6 : (P. roseus, T. tadorna)</td>
</tr>
<tr>
<td></td>
<td>Chott El-Beida</td>
<td>12223^1</td>
<td>26500^10</td>
<td>66^10</td>
<td>18^10</td>
<td>Ramsar^1</td>
<td></td>
<td>Cr 4 : (C. ciconia, G. grus, H. himantopus, P. roseus, T. tadorna)</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>Cr 6 : (P. roseus, T. tadorna)</td>
</tr>
<tr>
<td></td>
<td>Fetzara</td>
<td>12000^1</td>
<td>44500^3a</td>
<td>61^4</td>
<td>23^4</td>
<td>Ramsar^1, IBA^2</td>
<td>A4i (A. anser, S. clypeata, M. strepera, M. penelope,)</td>
<td>Cr 6 : (A. clypeata, A. penelope, A. anser)</td>
</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>A4iii</td>
</tr>
<tr>
<td></td>
<td>Garaet Hadj Tahar</td>
<td>112^5</td>
<td>12000^6</td>
<td>52^13</td>
<td>5^4</td>
<td>Ramsar^1, IBA^2</td>
<td>A1 (A. nyroca, O. leucocephala)</td>
<td>Cr 6 : (A. clypeata, A. penelope, A. anser)</td>
</tr>
</tbody>
</table>

^1: Ramsar site^2: Important Bird Area^3: Ramsar site^4: Important Bird Area
<table>
<thead>
<tr>
<th>Region</th>
<th>Site</th>
<th>Surface area (ha)</th>
<th>Maximum number of birds</th>
<th>Recorded Species</th>
<th>Breeding species</th>
<th>Current status</th>
<th>Retained IBA criteria</th>
<th>Retained Ramsar criteria based on waterbirds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mekhada</td>
<td></td>
<td>8900&lt;sup&gt;1&lt;/sup&gt;</td>
<td>25925&lt;sup&gt;3c&lt;/sup&gt;</td>
<td>49&lt;sup&gt;4&lt;/sup&gt;</td>
<td>13&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Ramsar&lt;sup&gt;1&lt;/sup&gt;, IBA&lt;sup&gt;2&lt;/sup&gt;</td>
<td>A1 (O. leucocephala, M. angustirostris, A. nyroca), A4i (A. anser, S. clypeata, M. Penelope, G. pratincola), A4iii</td>
<td>Cr 2 : (A. nyroca, A. ferina, O. leucocephala) Cr 4 : (A. acuta, A. penelope, A. nyroca, A. ferina, O. leucocephala, A. fuligula) Cr 5 Cr 6 : (A. penelope, A. strepera, A. anser)</td>
</tr>
<tr>
<td>Garaet El-Touyour</td>
<td></td>
<td>120&lt;sup&gt;1&lt;/sup&gt;</td>
<td>1352&lt;sup&gt;3d&lt;/sup&gt;</td>
<td>48&lt;sup&gt;4&lt;/sup&gt;</td>
<td>9&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Ramsar&lt;sup&gt;1&lt;/sup&gt;, IBA&lt;sup&gt;2&lt;/sup&gt;</td>
<td>A1 (O. leucocephala, A. nyroca), A4i (O. leucocephala), A4iii</td>
<td>Cr 2 : (A. nyroca, M. angustirostris, O. leucocephala) Cr 5 Cr 6 : (O. leucocephala)</td>
</tr>
<tr>
<td>Lake Tonga</td>
<td></td>
<td>2700&lt;sup&gt;1&lt;/sup&gt;</td>
<td>22705&lt;sup&gt;3e&lt;/sup&gt;</td>
<td>46&lt;sup&gt;4&lt;/sup&gt;</td>
<td>19&lt;sup&gt;15&lt;/sup&gt;</td>
<td>Ramsar&lt;sup&gt;1&lt;/sup&gt;, IBA&lt;sup&gt;2&lt;/sup&gt;</td>
<td>A1 (O. leucocephala, A. nyroca), A4i (O. leucocephala, A. nyroca, S. clypeata, M. strepera), A4iii</td>
<td>Cr 2 : A. nyroca, M. angustirostris, O. leucocephala Cr 5 Cr 6 : (A. nyroca)</td>
</tr>
<tr>
<td>Current study</td>
<td></td>
<td>55</td>
<td>4940</td>
<td>42</td>
<td>20</td>
<td>Not protected</td>
<td>Eligible to A1 (A. nyroca, O. leucocephala, M. angustirostris, A. ferina, V. vanellus) Eligible to A4i (O. leucocephala)</td>
<td>Cr 2 : (A. nyroca, O. leucocephala) Cr 5 Cr 6 : (A. ferina)</td>
</tr>
<tr>
<td>Oubeira</td>
<td></td>
<td>2200&lt;sup&gt;1&lt;/sup&gt;</td>
<td>6619&lt;sup&gt;3b&lt;/sup&gt;</td>
<td>37&lt;sup&gt;4&lt;/sup&gt;</td>
<td>8&lt;sup&gt;16&lt;/sup&gt;</td>
<td>Ramsar&lt;sup&gt;1&lt;/sup&gt;, IBA&lt;sup&gt;2&lt;/sup&gt;</td>
<td>A1 (O. leucocephala, A. ferina, A. nyroca), A4i (O. leucocephala, A. ferina S. clypeata, M. strepera, M. penelope, T. ruffcillii), A4iii</td>
<td>Cr 2 : (A. ferina, A. nyroca) Cr 5 Cr 6 : (A. ferina)</td>
</tr>
<tr>
<td>Region</td>
<td>Site</td>
<td>Surface area (ha)</td>
<td>Maximum number of birds</td>
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<td>Current status</td>
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<td>Retained Ramsar criteria based on waterbirds</td>
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<tr>
<td></td>
<td>Chott Tinsilt</td>
<td>2154(^1)</td>
<td>4123(^7)</td>
<td>32(^4)</td>
<td>18(^14)</td>
<td>Ramsar(^1), IBA(^2)</td>
<td>A4i (T. tadorna)</td>
<td>Cr 4 : (A. penelope, P. Roseus, T. tadom)</td>
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<td></td>
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<td></td>
<td></td>
<td>Cr 6 : (T. tadom)</td>
</tr>
<tr>
<td></td>
<td>Chott Hodna</td>
<td>362000(^1)</td>
<td>1261(^6)</td>
<td>24(^4)</td>
<td></td>
<td>Ramsar(^1)</td>
<td></td>
<td>Cr 2 : (C. undulata, M. angustirostris)</td>
</tr>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Cr 5</td>
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<td>Cr 6 : (T. tadoma)</td>
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<td></td>
<td>Garaet Guellif</td>
<td>24000(^1)</td>
<td>23020(^9)</td>
<td>22(^4)</td>
<td>10(^14)</td>
<td>Ramsar(^1)</td>
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<td>Cr 2 : (M. angustirostris)</td>
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<td>Cr 4 : (A. acuta, A. clypeata, A. penelope, G. grus, P. Roseu, T. tadoma)</td>
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<td>Cr 6 : (P. Roseu, T. tadoma)</td>
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<td></td>
<td>West Wetlands</td>
<td>Dayet El Ferd</td>
<td>3323(^1)</td>
<td>16799(^8)</td>
<td>29(^8)</td>
<td>Ramsar(^1), IBA(^2)</td>
<td>A4i (T. ferruginea, G. grus)</td>
<td>Cr 4 : (F. atra, F. cristata, G. grus, P. roseu, T. ferruginea)</td>
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<td>A4i (T. ferruginea, G. grus)</td>
<td>Cr 6 : (G. grus, T. ferruginea)</td>
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<td>Macta</td>
<td>44500(^1)</td>
<td>27867(^12)</td>
<td>18(^4)</td>
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<td>Ramsar(^3), IBA(^2)</td>
<td>A1 (M. angustirostris, T. tetra), A4i (M. angustirostris)</td>
<td>Cr 2 : (A. nyroca, M. angustirostris, O. leucocephala, V. vanellus)</td>
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<td>South Wetlands</td>
<td>Chott Golea</td>
<td>18947(^1)</td>
<td>6721(^11)</td>
<td>67(^17)</td>
<td>Ramsar(^1)</td>
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<td>Cr 2 : (A. nyroca)</td>
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<td></td>
<td>Cr 4 : (C. alexandrinu, G. chloropus, I. minutus, T. ferruginea, F. atra)</td>
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<td>Cr 6 : (A. nyroca, T. ferruginea)</td>
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The diversity of 12 families of waterbirds found in the Boussedra marsh reflects the different ecological niches occupied by the species cohabiting in the same habitat with different mechanisms, modes, and intensities of interaction with other species. The water body supports a significant diversity of dabbling ducks, foraging in the first few centimetres of open water and diving
ducks penetrating deeper. The freshwater hosts also Moorhens and waders walking along peripheral areas in search of their prey. Lapwings prefer peripheral meadows, while Gulls and raptors hunt everywhere, around and within the wetland.

Five of the species found in the marsh are classified by the IUCN as globally threatened (Category A1, IBA), representing 3% of the globally threatened aquatic avifauna (Akli 2008), and one-third (33%) at the national level (Isenmann and Moali 2000). These species were *Oxyura leucocephala* (EN), *Aythya nyroca* (NT), *Vanellus vanellus* (NT), *Aythya ferina* (VU) and *Marmaronetta angustirostris* (VU). Samraoui and Samraoui (2008) were the first to declare the Boussedra Marsh eligible for the IBA, in category A1, based on the presence of two species, *Oxyura leucocephala* and *Aythya nyroca* listed by the IUCN as globally threatened.

**Monthly abundances “total, specific and relative”**

The importance of the Boussedra marsh appears in its large carrying capacity of waterbirds despite its small size. The annual monthly abundance varied from 580 to almost 5,000 birds during the study period. Our censuses are comparable to those provided by the Forest Conservation Services of Annaba, which are conducted in January during the International Census of waterbirds, where results varied between 144 and 4,105 individuals between 2011 and 2018. The peak number obtained ranks this site second locally after Lake Fetzara (Ramsar site since 2002), where up to 18,000 birds have been counted (Unpublished 2011 data relevant to the local directorate of forest conservation). The main hydrosystems of Annaba barely exceeded 1,000 individuals; Salines 1,056 individuals, Sidi Achour 345 individuals and Oued Boukhmira 496 individuals (Touati and Samraoui 2013). However, at the national scale, double and up to fivefold increases have been recorded in several wetlands, such as Garaet Hadj-Tahar, Dayet El-Ferd, Mekhada, Chott El-Beida, Lake Tonga, Sebkhet Bazer-Sakra and depression of Oued Righ (Metallaoui 2008; Salines 2009). The recorded population of 505 individuals in Tlemcen at Dayet El Ferd, in the far northwest, thus moves into 3rd place (Oudihat et al. 2017). Populations were moderately to weakly represented in the other sites of the Annaba wetland complex and many Algerian wetlands hosting the species (Metallaoui et al. 2009; Seddik et al. 2012; Guellati et al. 2014; Yahiacherif-Sadaoui 2015; Abdi 2017; Atoussi et al. 2017; Oudihat et al. 2017; G.D.F. 2018; Oudihat 2018; Senoussi 2019). Over the last two decades, these recent studies have confirmed a gradual increase in the number of White-headed ducks in Algeria. The general dynamics of the expansion of the population would be in relation to the success of the international measures that are in place for the conservation of the species. The most spectacular case that we studied in Algeria occurred in Dayet El Ferd, where the population has increased rapidly from the first observation of 1 individual in 2004 to 76 individuals in 2015 (Tlemcen National Agency of Nature in Bendahmane 2015b), and then to 505 individuals in 2014 (Oudihat et al. 2017). In Spain, the population increased from 22 individuals in 1977 to 786 individuals in 1992, and then to 4,480 individuals in 2000 (Ayala et al. 1994; Green and Hughes 2001).

From January to April 2017, the Boussedra, which extends to the peripheral meadows, hosted groups ranging from 24 to 820 Northern Lapwings. Their large groups, observed in winter or on their way to the breeding grounds, are generally frequent, evidence of their preference for open and hygrophilic environments with an herbaceous layer, which is more abundant after heavy rainfall. The number of lapwings counted is the fourth highest among the available national inventories, after the three recent peaks of 1,500, 1,170 and 873 counted in Garaet Hadj-Tahar, Mekhada, and the Setif eco-complex, respectively (Unpublished 2009 data relevant to the local directorate of forest conservation; Metallaoui and Houhamdi 2010; Baaziz et al. 2011). Less than 280 individuals were counted in El Kala wetlands, Tiffech and El Kef reservoirs, Garaet Timerganine and Sebkhet Bazer-Sakra (Seddik et al. 2012; Gouga 2014; Guellati et al. 2014; Gherib et al. 2021).
The abundance of Common Pochard and Ferruginous Duck in the Boussedra marsh was very low compared to several wetlands of northern Algeria, which host much larger aggregations. Peaks of 35,000 individuals were recorded for the Common Pochard (Metallaoui and Houhamdi 2010; Baaziz et al. 2011; Oudihat 2011; Seddik et al. 2012; Yahiacherif-Sadaoui 2015), and 2,000 individuals for the Ferruginous Duck (Seddik et al. 2012; Gherib et al. 2021). However, the actual situation of the Marbled-Teal in Algeria is different, occurring in small groups, often with less than 100 individuals per wetland (Metallaoui and Houhamdi 2010; Oudihat 2011; Bensizerara 2014; Bendahmane 2015; Beghdadi 2016; Bediaf et al. 2020; Gherib et al. 2021). Recent populations exceeding this threshold have been fewer, with a peak of 1,050 individuals (Nouidjem 2007; Baaziz et al. 2011; Seddik et al. 2012; Bensaci et al. 2013; Aberkane 2014).

**Occurrence frequency**

The present study measured different temporal patterns of occurrence (sedentary, winter and summer visitors) and different levels of frequency (frequent, common, occasional, rare and accidental). The obtained numbers and percentages of sedentary species are comparable with data from the main Algerian wetlands, such as the wetlands of the eastern region of the country, 9–17 sp., 13–32% (Metallaoui and Houhamdi 2008; Metallaoui et al. 2009; Guellati et al. 2014; Gherib et al. 2021), the central Height Plateau, 15–17 sp., 27–31% (Seddik et al. 2012; Sahbi et al. 2018; Zoubiri 2018), the western region, 11 sp., 28% (Beghdadi 2016), and the Saharan wetlands in the south, 11 sp., 19% (Bensaci et al. 2013). Similarly, the studied frequencies of the summering and wintering species were consistent with the observed trend in all the mentioned wetlands, indicating that they are more likely to be wintering rather than nesting areas. Almost all of the species found in Boussedra have already been reported with the same status in several more or less nearby Algerian wetlands, e.g., (Allouche and Tamisier 1989; Samraoui and De Belair 1997; Isenmann and Moali 2000; Houhamdi and Samraoui 2002; Metallaoui and Houhamdi 2008; Metallaoui et al. 2009; Seddik et al. 2012; Zoubiri 2018; Bediaf et al. 2020; Gherib et al. 2021).

**Breeding**

The large number of breeding species recorded in the Boussedra marsh supports its outstanding role in conserving avian biodiversity. With 20 species, the list of breeding species in this small area represents half (49%) of the total number of breeding species in one hundred and one of Algeria's major wetlands, estimated at 41 species by Samraoui et al. (Samraoui et al. 2011). Boussedra marsh is now one of the most important Algerian wetlands for breeding waterbirds, such as Fetzara (23 sp.) and Sebkhet Bazer-Sakra (21 sp.), Lake Tonga (19 sp.), Chott El-Beida (18 sp.), Chott Tinsilt (18 sp.), Garaet Timerganine (17 sp.) (Samraoui and Samraoui 2008; Baaziz et al. 2011; Seddik et al. 2012; Saïfouni and Bellatreche 2014) (See also Table 1).

As with the White-headed Duck wintering population mentioned above, the Boussedra marsh is particularly notable for hosting the largest breeding population among the available studies to date. The breeding population in this wetland increased from 17 to 23 nests in 2012 and 2013, respectively (Chettibi 2014), then to 38 nests in 2018 (this study). The main breeding wetlands in the country for the species are located in the eastern region, namely Lake Tonga (37 nests), Garaet Hadj-Tahar (six pairs with chicks) and some wetlands in the high plateaus (about ten pairs with chicks) (Metallaoui et al. 2009; Lazli et al. 2011; Seddik et al. 2012; Chettibi 2014).

Boussedra is also a breeding area for three other species on the IUCN Red List of threatened species (IUCN 2023), namely Marbled Teal (VU), Common Pochard (VU) and Ferruginous Duck (NT). Nest numbers were close to national records for the first two species but low for the latter (See Table 2 for national bibliographic records) (Lardjane-Hamiti et al. 2012; Bakhouche et al. 2013; Bouzegag et al. 2013; Fouzari et al. 2015). The nesting of the Marbled Teal has only been confirmed in a small number of wetlands scattered across the country in the east, in the high plateaus and the west (Heim de Balsac and Mayaud 1962; Isenmann and Moali 2000; Houhamdi and Samraoui 2002). According to Isenmann & Moali, (Isenmann and Moali 2000) the Common Pochard has regained its breeding status in Algeria since 2009, after 49 years of absence. We can note the case of Lake Reghaia (Lardjane-Hamiti et al. 2012), although recent studies on its nesting are still very poor.

**Diversity Indices**

The average values of the diversity indices show an imbalance in the distribution of abundance in favour of a limited number of dominant species, one-fifth of all populations surveyed, against a large number of dominated species. These values express a state of equilibrium of the Boussedra marsh which can be considered as developing and endowed with resources that are not too
diversified. These resources are more beneficial to adapted species and allow them to settle and/or reproduce in fairly large numbers. Similar diversity index values have been reported in some wetlands, such as Lake Tonga, Sebkhet Bazer-Sakra, and Garaet Hadj Etaher (Metallaoui and Houhamdi 2010; Gouga 2014; Elafri 2017). However, higher values of diversity indices were also noted, as in another study carried out in Lake Tonga, and in Lake of El Golea, marsh of Reghaia, Sebkhet Djendli and K’sob dam (Bensizerara 2014; Yahicherif-Sadaoui 2015; Zoubiri 2018; Bediaf et al. 2020; Gherib et al. 2021), or lower such as Chott El Hodna, El Gherssa reservoir, Boughezoul dam (Zoubiri 2018).

Conclusion

This multi-year study provides a fairly complete scientific basis to support the desirable project of including the Boussedra Marsh in the IBA network. It consolidates the site's eligibility for this network, taking particular account of globally threatened bird species. IBA categories A1 and A4i were found to be significant, validating the international importance of this wetland for waterbirds.

Additionally, this study assesses the carrying capacity of Boussedra and compares it in a local, national and international context, through the study of descriptors of the composition and structure of the avian communities that live there. Its richness in waterbirds, consisting mainly of surface ducks, Rallids, waders, gulls and raptors, ranks it among the top 10 of the most diversified wetlands in the country, sheltering one-third of the national aquatic avifauna. Among this list, five species are listed as globally threatened by the IUCN red list, namely, Oxyura leucocephala (EN), Marmaronetta angustirostris (VU), Aythya ferina, (VU) Aythya nyroca (NT) and Vanellus vanellus (NT). Although low compared to the major Algerian sites, the waterbird abundances of the marsh remain among the most important locally. Boussedra is a wintering quarter, but is also home to a diverse nesting of up to 20 species, making it one of the most important breeding areas in Algeria. Four globally threatened species nest in this wetland, Common Pochard, Marbled Teal and Ferruginous Duck, all invested by weak nesting, and White-headed Duck breeds at the site with national record numbers.

However, if conservation measures are not taken immediately, and given the speed of degradation, particularly the massive backfilling and urban sprawl occurring in the peripheral areas, all of its local bird richness is threatened to disappear. We see this paper as a call to all local and national environmental and biodiversity stakeholders to become aware of the accelerating loss of this important wetland and especially the vital services it provides, such as we suggest the immediate establishment of a continuous monitoring and surveillance program in order to save Boussedra.

Declarations

Acknowledgments

We would like to thank the forest conservation directorate of Annaba and El Tarf, as well as of the National Park of El Kala for having provided us the annual waterbird census data carried out by their services.

Ethical approval Our study did not involve humans or animals, and thus this is not applicable for this manuscript.

Competing Interests The authors have no relevant financial or non-financial interests to disclose.

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Author Contributions Conceptualization GT and KD. Methodology KD, ID, BB and GT. Software GT and KD. Validation GT and KD. Formal analysis KD and GT. Investigation KD, ID and BB. Data curation KD and GT. Writing—original draft preparation GT and KD. Writing—review and editing GT, KD, ID and SN. Visualization GT and KD. Supervision GT and ZB. All authors have read and agreed to the published version of the manuscript.

Data availability The datasets generated during the current study are available from the corresponding author on reasonable request.
The authors declare no conflict of interest.

References


32. Gouga H (2014) Biodiversité faunistique à Sebkhet Bazer (Sud de Sétif) connaissance et conservation. Magister, Farhat Abbas Sétif 1


49. Oudihat K (2011) Ecologie et structure des Anatidés de la zone humide de Dayet El Ferd (Tlemcen). Magister, Université Aboubaker Belkaid Tlemcen


62. Talbi A (2022) Dynamique et inventaire de la population de Foulque macroule (Fulica atra) et de la Poule d’eau (Gallinula chloropus): Cas du marais de Boussedra Nord-est Algérien. Thèse, Université 8 Mai 1945 Guelma


Tables
Table 3 is available in the Supplementary Files section.

Figures

Figure 1

Location of the study area; the marsh is located in the extreme north east of Annaba province and Algeria
Figure 2

Waterbird richness of the Boussedra marsh during the study period; Ss on the first bottom line is the summer bird richness, Sw on the middle line is the winter bird richness, San on the last top line is the annual bird richness; Species richness were presented separately for each study period from left to right as follows: 2015-2016, 2016-2017-2017-2018, then for the whole study period from 2015-2018 in the last row on the left.

Figure 3

Waterbird Family frequencies in Boussedra marsh; Each family's percentage representation was displayed
Figure 4

Monthly abundances of the recorded waterbird populations over the study period; the dashed line pattern indicates the abundance of birds during the study period 2015-2016, continuous for the period 2016-2017 and dotted for the period 2017-2018.

Figure 5

Comparison of the diversity index $H'$ obtained in the study periods of wintering (white half on the left) and nesting (grey half on the right), presented at the bottom, with the theoretical index $H'_{\text{Max}}$ in an optimal situation, presented at the top.

Supplementary Files
This is a list of supplementary files associated with this preprint. Click to download.

- Table3inAppendix.docx